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This course of study was developed under the supervision of the State Department of Education and in cooperation with junior high school teachers, senior high teachers, school administrators, and college and university personnel. It is being made available in order to help teachers lead youngsters to become "actively engaged in the science process and to acquire the needed understandings, skills, attitudes, and appreciations in science." The introduction deals with such matters as (1) curriculum organization, (2) safety rules, (3) teaching of science, (4) instructional techniques and procedures, (5) the scientific attitude, and (6) student achievement evaluation. Part II gives the topical outlines for (1) seventh grade general science, (2) eighth grade earth and life science, and (3) ninth grade physical science. The Course of Study, Part III, is organized according to (1) topical outline, (2) corresponding understandings to be stressed, and (3) corresponding suggested activities. The Handbook Section, Part IV, provides comprehensive experiments, extended activities, and demonstrations. Appendixes provide additional material on (1) evaluation guidelines for a good science program, (2) equipment list, and (3) references. (DH)

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SCHOOL BULLETIN

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March, 1967

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A Course of Study and Teaching Guide for Grades 7, 8, 9

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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Division of Instruction
STATE DEPARTMENT OF EDUCATION
Jackson, Mississippi

J. M. TUBB, Superintendent

Mississippi
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A Course of Study and Teaching Guide for Grades 7, 8, 9

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STATE DEPARTMENT OF EDUCATION
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FOREWORD

The course of study guide, *Science in the Junior High School,* was developed under the direction of R. C. Roberts, Supervisor of Science, Division of Instruction, Mississippi State Department of Education, with the cooperation of a staff of junior high teachers, senior high teachers, school administrators, college and university personnel, and a consultant from the U. S. Office of Education. A special study of the junior high school science curriculum was initiated in the summer of 1962 and was continued in successive summers up to the time of its completion in 1966. Special recognition is due those members of the Curriculum Development Committee for their dedication to this task during the four years in which they were engaged in the project. Grateful appreciation is expressed to all committee members for their contributions.

Special attention is called to two major sections of the bulletin, "The Courses of Study, Part III" and the "Handbook Section—Comprehensive Experiments, Extended Activities, and Demonstrations." The courses of study may be used in their entirety as teaching guides, or the teacher may adapt any part of the courses of study to the school's program. The Handbook Section contains many suggested experiments and demonstrations designed to enrich the science program in grades 7, 8, and 9. Further suggestions for the use of the bulletin are found in the Introduction.

The bulletin is provided to the schools of the State to help the teachers to lead boys and girls to become actively engaged in the science process and to acquire the needed understandings, skills, attitudes, and appreciations in science.

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ACKNOWLEDGMENTS

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Special recognition is due Mr. Shedd, who served as chief consultant, and Mrs. Lawshe, Mrs. Moose and Mrs. Myers, the chief writers of the materials for the respective grades during practically the entire period of development of the bulletin.

The course of study material was reviewed by Sister Mary Leah, St. Joseph High School; Mrs. R. J. Knight, Mt. Olive High School; Mr. A. A. Alexander, State Department of Education; Miss Alene Hunt, Sam Brinkley Junior-Senior High School; Mr. Edgar Griffin, Alexander High School; and Mr. Joseph Williams, Magnolia Junior High School. Mrs. Rose Fleming, U. S. Soil Conservation Service, Jackson, helped in developing the conservation unit. Mrs. Sara Richardson, Hinds Junior College, worked with the State Department of Education in the final editing and arranging of the materials.

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PART I INTRODUCTION

In this age of rapidly expanding horizons, and technological advances, science educators have a vital responsibility toward the youth of our nation. The numerous thresholds of discovery extend many-faceted challenges to the teacher, who must prepare today's children for everyday living in a world which is striving to conquer inner, as well as outer, space.

The concept of junior high school, based as it is upon the physical, biological, and emotional development of adolescents, requires special knowledge, skills, and dedication of its teachers. It offers rare opportunities, especially to the teacher of science, for meeting the individual needs of youth.

ORGANIZATION OF THE CURRICULUM

The curriculum committee kept in mind several aims as the writing of this study guide proceeded: to develop a three-year sequential program of study; to avoid needless repetition; to provide material, which is ample, flexible, and comprehensive.

THREE-YEAR PLAN

This three-year plan is designed to be a transition from the generalized science program of the elementary school to the relatively specialized program of the senior high school.

The underlying structure of the three-year plan is to introduce the student to the broad area of secondary science study with a definitive approach to its major disciplines at the seventh grade level. Therefore, each of the seventh grade units is "An Introduction to . . . " earth science, physics, chemistry, and biology, respectively. This is the only one of the three courses which could be called "general science" in any form. It should give the student an overview of science study while helping him to acquire some feeling of what specialized study in one of the fields would be like. Since its various units are six to nine weeks in length, there is time for students to discover their affinity for particular areas of study. Yet, the interest span for most seventh grade groups is not over-reached.

The eighth grade course is two separate semesters of work. The first is given to earth and space science, the second to life science. Specialization to some depth can be done within a semester. If the students have had the seventh grade course of study, they should have some basic understanding and knowledge in the other fields so that application can be made in the eighth grade studies. For example, the basic understandings in chemistry and physics are needed for rocketry in space studies, for topics in geology in general, mineralogy in particular, and for anatomical and physiological studies of the human body.

The ninth grade course of study develops into a year of study of the physical sciences. The principles of chemistry and physics, which were introduced in the seventh grade, are extended to a degree which should provide a good base for modern high school courses in chemistry, physics, and biology.

One major aim was to include enough activities with each concept to allow the teacher a choice. It is neither expected nor suggested that all activities be used in teaching any single topic. Many creative teachers may choose to add or to substitute original ideas which they have found effective in helping students understand certain ideas, facts, and principles or laws in science. The organization of the guide is built on its concepts at grade levels. Any activities, methods, and techniques which a teacher can apply to help the student achieve these understandings are acceptable. It is hoped there will be an increase in the use of quantitative measurements and mathematical processes. It is also hoped that wider application of the principles of problem solving, involving discovery and critical thinking, will be made.

Every effort was made by the curriculum study committee to avoid repetition of concepts and activities. However, the organization of the courses of study is such that the seventh grade units may be used for background review where necessary.

Realizing the impossibility of formulating any course of study which would be applicable in its entirety to every local situation, the committee first established one broad goal. This was to produce a study guide which would be developmental in sequence and nature and flexible in use for the teacher while offering the student a comprehensive study in modern science.

The courses may be taught in whole or in part as presented in this publication, or they may be adapted to the objectives of science study in the local school system. Regardless of the way in which this guide is used, in whole or in part, it is hoped that the publication will prove helpful to teachers of junior high school science.

PROPOSED PROGRAM OF STUDIES

The proposed program of studies will provide for the general education of all students, as it contains a common learnings program for all students through the 10th grade, including one biological science and one physical science above the 8th grade.

At the same time, it will meet the needs of science-oriented students and allow for their acceleration at any of the junior high years.

Common Learnings Program

7th grade—General Science

8th grade—Earth, Space, and Life Sciences

9th grade—Introduction to Physical Science

10th grade—Biology

For More Thorough Science Preparation

11th grade—Chemistry

12th grade—Physics

Alternate Accelerated Program

9th grade—Biology

10th grade—Chemistry

11th grade—Physics

12th grade—Advanced Science Course (Advanced Biology, Special Problems Course in Physical Science, or other courses.)

An accelerated program may or may not be desirable when all factors are considered. They are successful in some situations and not in others. If there is a sufficient number of high ability students, well qualified staff, and other favorable conditions for establishing an accelerated program, it is suggested that the following criteria may be used for the selection of students for the accelerated program.

1—Academic achievement

2—Test scores

3—Counseling with the students

4—Consent of the parents

SOME IMPORTANT SAFETY RULES IN THE LABORATORY

Safety in the laboratory is essential to prevent serious accidents. First aid supplies should be readily available. A fire extinguisher should be placed in every science department.

Notes to Students:

Most accidents can be prevented if you make safety a habit.

1. Read and follow all posted directions.
2. Never mix, touch, taste, heat or inhale chemicals unless you are told it is all right to do so by your instructor.
3. Always wear protective devices such as goggles, gloves, and an apron when these safety devices are needed.
4. Handle all hot objects with clamps or tongs.
5. Take extra precautions in handling dangerous chemicals.
6. Do not perform any experiments unless your instructor is in the room.
7. Turn off the gas when it is not in use.
8. Read the labels on all bottles carefully before using.
9. Never point a test tube you are heating toward anyone.
10. Pay strict attention to your own work. Don't let your interest or attention wander.

FIRST AID FOR ACID AND ALKALI BURNS

1. Flood the tissue with water.
2. Notify your instructor.
3. FOR ACID BURN: Neutralize with a weak alkali (base) such as a sodium bicarbonate solution.
4. FOR ALKALI BURN: Neutralize with a weak acid such as a boric acid solution.
5. When mixing acid and water—always add the acid to the water, using the greatest caution.

6. When inserting a glass tube into a cork, always lubricate the tube and cork with water.
7. The science laboratory is a place for intelligent adult behavior.

OBJECTIVES AND PRINCIPLES FOR TEACHING SCIENCE

Every science teacher should periodically establish the answers to three questions in his or her own mind: (1) "Why am I teaching my students science?"; (2) "What am I teaching my students in science?"; and, (3) "How am I teaching science to my students?" The answer to the first question will help the teacher to evaluate his objectives. The answers to the other two will help the teacher to evaluate his total course content and teaching methods.

The whys of science teaching are included in those general objectives of education which seek: (1) to enable the student to find his place in today's world; (2) to fill that place in a manner which will be satisfactory to himself and to others concerned. In order to reach these objectives, the study of science must *help the student discover and develop his potential interests and aptitudes*. It must also *help him build a foundation for higher academic studies and career opportunities*. Each of the generalized objectives and their specialized components is important in science teaching. The degree to which the general objectives of science education for students are attained will be determined by the "whats" and "hows" of science teaching.

Probably, the widest response to the question of what we are teaching students in science would be "subject matter" in its broadest sense, with its advantage of easily observable achievement. The history of education and current evidence support the continued vital need for academics. However, there are other needs, more subtle in nature perhaps, which also must be met. Because of the unique characteristics of the junior high school age group, the junior high school science teacher has a responsibility and an opportunity unlike that found in any other level of teaching.

The objectives for junior high school science are not only functional in nature, a criterion which should be applied to all teaching, but they are social in their implications as well as scientific. In addition, the achievement of these objectives requires a related involvement of learning skills from other areas of study, such as the language arts, mathematics, and social studies. Because of its intermediate and transitory position in the progression of grade levels, junior high school science has certain objectives, as listed below:

SKILLS:

1. Observing accurately and discriminately, developing the ability to distinguish components and relationships
2. Gathering sufficient data and dealing with it quantitatively
3. Recording and treating data completely and honestly
4. Performing fundamental operations and simple manipulatory activities with reasonable accuracy
5. Measuring accurately; reading with comprehension

6. Identifying and defining "hidden" problems as well as the obvious ones
7. Stating and testing hypotheses discriminately
8. Making generalizations and drawing conclusions
9. Communicating effectively through oral and written techniques
10. Functioning effectively as an individual and as a member of a group
11. Thinking
    (a) critically
    (b) creatively
    (c) inductively
    (d) deductively

UNDERSTANDINGS:

1. The determinate nature of living things
2. The interdependency of living things
3. The orderliness and organization of physical nature in both physical and biological sciences
4. Cause and effect relationships, simple and multiple
5. Prediction of occurrences as the result of particular causes
6. Conversion and diversion as means of control and preservation
7. The actual and relative value of knowledge (facts)
8. Conservation of human, physical and natural resources

ATTITUDES:

1. Personal responsibility
2. Intellectual honesty
3. Openmindedness
4. Receptiveness to challenge
5. Reasonableness; rationality
6. Suspended judgments
7. Independence in academic pursuits
8. Respect for rights and property of others
9. Wholesome curiosity
10. Cooperativeness
11. Objectiveness

APPRECIATIONS:

1. The role of science in the development and maintenance of civilization and cultures
2. The achievements and contributions of scientists

3. The breadth and limitations of science
4. The value of pure science and technology
5. Aesthetic and moral values of our natural environment
6. The existence and processes of nature

BEHAVIORS:

1. Applies science learnings to solving social and academic problems
2. Develops potential aptitudes and interests
3. Extends endeavors in science beyond the classroom and continues beyond required study
4. Accepts science for its constructive addition to living as well as its potential in the future

PROCEDURES AND TECHNIQUES OF INSTRUCTION

METHODS—The science teacher must be able to adjust the content and methods used to the many types of organizations and curricula that he will encounter in various teaching situations. Methods must be flexible and interchangeable in order to meet the needs of the junior high school student.

Knowledge of psychology and methods of science teaching have advanced just as has the knowledge of science. More is known about motivation, learning, and transfer of learning. The teacher of junior high school science must make an honest effort to keep informed, not only in the area of subject matter, but also in the realm of current educational practices. There must be a constant search for methods which will improve the teaching of science.

Communication, motivation, and participation are some desired outcomes to be observed in students as a result of the teacher's ability to organize the study, to adapt to the learner's ability, to narrate interestingly, to recognize the worth of each individual student, and to accept the obligation to see that desirable learning occurs.

Methods and procedures are important in that they make possible the operation of effective principles of science teaching. Just as subject matter differs, so should methods of presenting it differ. Variety avoids monotony, and to be effective, variety must be planned.

The following methods are suggested, but one must keep in mind that the success of any method or composite of methods depends upon the teacher's being individual, dynamic and creative in the use of the methods.

Inductive teaching should be the underlying current and basic pattern of all science teaching, so that scientific principles, concepts, and generalizations will be the end point of teaching rather than the starting point. The scientific method of *problem-solving* remains the basic procedure through which discovery is made and is very important for inductive teaching. Therefore, the teacher will need to employ the steps of scientific thought and fluid inquiry throughout all his teaching.

The *unit method* of teaching science lends itself so well to the subjects of science there is the danger of placing all subject matter in separate units and as a result continuity is lost. For example, this method would be most useful in the seventh grade general science, rather than in the ninth grade physical science. This method demands teacher preparation and planning. Units are generally planned in three stages: (1) introducing the unit, (2) developing the unit, and (3) terminating the unit. Evaluation follows as it does in any teaching method.

The unit method provides for some student participation in planning. Students at the junior high school level in particular, like to share in planning, such as devising or suggesting means to answer pertinent questions. The "Let's try it out" request by a student is the teacher's key to open the student's mind to further inductive-deductive learning. This student participation also includes the use of the text book. Work in the text should be presented as opening new doors to more exciting knowledge rather than as "seat work."

The *lecture method* has little value in a junior high school science class since emphasis should be on student participation rather than on a teacher centered activity. However, modifications of lecturing prove effective when the teacher can project subject matter in an interesting and possibly narrative form.

Discussion, reporting and *note taking* are considered as integral parts of any method. These devices should be used and directed to bring about desired learning and not as a "time killer" or a task to be endured.

Creative teaching may not be considered a method, but creative teaching discovers or awakens interest in order that each student may develop his unique talents. This method requires more of the one-to-one and one-to-small group relationships. Creative teaching does not need to be unorthodox as the name might imply, but the teacher must have keen insight into the nature and abilities of the student and then devise ways of developing these abilities.

The activities as listed on later pages should be interwoven into the various methods used, just as audio visual aids, charts and models supplement and strengthen the method used.

In all activity where student participation is involved, intellectual honesty should be stressed and taught as a basic principle of education.

LEARNING ACTIVITIES—Most science topics lend themselves to a variety of types of student activities. The problem becomes one of selection of the particular type of activity which will be most effective and practical with available resources. The selection of an appropriate type of activity is important, but the skill in conducting the activity is of greater importance. The success of the class exercise will depend greatly on the class preparation done in advance, and the techniques employed during the class period.

Science cannot be properly taught at the junior high school level unless the students are given ample opportunity for individual investigation and experimentation. Experimentation, investigation, and student and teacher demonstrations have in common the use of the laboratory, equipment, chalk-board and some activity on the part of everyone in the class. However, these activities differ in their presentations.

One or more class periods per week (or the equivalent) should be devoted to experimental work. Demonstrations are useful in some cases, but students need the experience of going through the sequence of mental and physical processes involved in an experiment.

A number of experiments should be done employing the "discovery principle," which results in the formulation of laws or principles rather than verification.

An experiment may be done with the express purpose of arousing interest in the validity of the results, the variables acting on the outcome, and ways to put the experiment to the test. From these activities students learn new skills, entertain an appreciation for pioneers in science, apply and prove the scientific method, apply original ideas to basic assumptions and develop original work which may require long periods of time for completion.

There are times when nothing but a teacher demonstration will do to begin a lesson, to end a lesson, to develop a point or to demonstrate processes too dangerous or complex for students to handle. But for whatever purpose, its major function is to present evidence for a concept by doing, seeing, and testing. Students present very good demonstrations and are good "teachers" because at the junior high school age, students enjoy performing and observing their peers perform.

Time for creative activities with the use of laboratory equipment should be provided so that students can discover with actual contact and manipulation some of the principles we accept as common. In this manner, the alert student is often led into investigations uncommon to the area of study.

The use of films and filmstrips in the role of activity in the classroom needs clarification. Although films are entertaining and help to hold interest, their purpose is not entertainment. Neither should films be shown in the same manner (for instance, to introduce a topic) each time. There is a great variety of free film material, and variety in accord with function should determine when the film is needed. Films and filmstrips may introduce a topic, present a problem to be solved, be a vicarious field trip, an accessory microscope or micro-projector, act as an accessory to an experiment, as a test, and in some cases a full-period lesson.

Topical charts, student posters, picture slides, opaque projections, and overhead projections lend variety and purpose to the lesson. Student participation is stressed to a greater extent if students are given the opportunity to help organize, are allowed to contribute to the subject matter, and are taught to operate the machines where it is practical to do so.

The use of recordings has been overlooked as an activity. They serve a unique purpose in reproducing sound, otherwise not available, such as bird calls, animal "language" and animal sounds. Records based on the science of sound are invaluable aids. Current television programs like the recent space shots are opportunities to put into practical application the recognition of many science principles previously learned.

The bulletin board and exhibit case should be the responsibility of the student, with the teacher as consultant. Bulletin boards are not only for notices, but also for current events, problems of the week, and special events and dates relating to science. The exhibit case should be used for exhibit of materials related to the topic at hand: projects; books and printed material; laboratory set-up for the day; student collections; hobbies; local industrial exhibits.

The teacher and student, no matter what the lesson is, can make good use of the chalk-board as an aid in demonstration, in illustration, as an aid to discussion and reporting, as an aid in projections, as a reminder, or to emphasize and reinforce.

The use of transparencies in overhead projectors can be used very effectively. There are many ready-made transparencies and through the use of transparency makers, teachers may make their own. In using overhead projectors, the teacher can face the audience in a partly lighted room.

The activity pursued should lead students to examine carefully all evidence and to formulate hypotheses or conclusions in terms of the evidence rather than blind acceptance of "laws" or "authority."

Make special assignments in line with ability level so that every student may have a sense of belonging and a sense of achievement.

The elements of critical thinking do not follow a rigid pattern, but some efforts to analyze the process have revealed that it encompasses the following:

1. Sensing and defining the problem
2. Collecting and organizing evidence on the problem
3. Interpreting the evidence and forming tentative hypotheses related to the problem
4. Testing the hypotheses
5. Formulating conclusions

Regardless of the type of activity employed, scientific attitudes and scientific practices should be in evidence. Here are some tips which have been found helpful:

(1) The teacher should join with the students in exploring and learning.

(2) Every student response should be considered for what it is worth. It may not be simply right or wrong.

(3) If class interest seems to be lagging, perhaps the lecture or discussion activities are being overdone, and students are not getting the types of class participation needed.

(4) Avoid the role of the teacher as absolute authority, knowing all the answers, asking all the questions and deciding the final answer.

(5) The teacher should not be an information bureau supplying all the answers. Lead students to answer their own questions, when only a thought process is required, or when an investigation can be made.

(6) In doing a demonstration, don't tell students what is going to happen before it is done, but keep them guessing or have them to predict what may happen.

(7) Demonstrations are not a substitute for laboratory experiments, but can be considered as group experience since students take notes, observe, suggest procedures and draw conclusions.

(8) The chalk-board is the handiest, cheapest, and most dependable visual aid in the classroom, and it is possibly the most neglected and misused.

(9) Use films and filmstrips in a lesson, not as a substitute for a lesson.

SCIENCE PROJECTS—The science project should be included among the activities as a regular part of the science course. The science project is an effective means of involving the students in problem-solving situations. One minor problem after another arises in connection with the major problem. Solving these minor problems and resolving the difficulties encountered prove to be a most satisfying experience.

The student gains much basic education or conditioning, as well as special abilities and knowledge of science from his project. It involves the making of decisions, careful planning, the assuming of responsibilities, acquisition of community resources, skills of construction, appreciation of artistic display, the use of good English and clear writing, the sense of achievement, and the satisfaction of communicating his accomplishments to others.

Special ability and interest in science may be greatly enhanced through the doing of science projects. In proposing and evaluating science projects, the ability and inherent interest levels of the individual student should be considered.

EQUIPMENT AND MATERIALS — With all the NDEA funds or ESEA funds made available, it would seem that the junior high school science class would have the necessary equipment and materials. However, this is not always the case. The lack of equipment and materials will impose some limitations on experimental or other types of activities, but the initiative of a good teacher may serve to offset the handicap of equipment deficiency.

Many times non-commercial equipment, home-made or home-brought equipment and materials, may serve the purpose. Substitutions of equipment for the experiment may often be made. The work of the PSSC in junior high school science has shown that simple equipment may be used in the doing of a variety of experiments.

The teacher should have ready access to the items on the list of basic junior high school experimental equipment, included in the appendix. If the basic items on this minimum list are not available, then priorities of purchases should be given to them.

It is believed that most teachers will find use for the items on the basic list, but it is suggested that each teacher requisition equipment needed in terms of the demonstrations and experiments to be done.

If the room is not already equipped with tables or work areas (or laboratory not available) then efforts should be made to secure makeshift tables until proper laboratory tables may be provided.

Refer to Mississippi Bulletin, No. 153, Science Facilities for Mississippi Schools, 1962 publication.

The school system should make all efforts to correct makeshift laboratory table deficiencies in science classrooms.

FIELD TRIP—The field trip provides science experiences that cannot be otherwise gained. Many benefits may come from a well-planned and well-conducted field trip. Some of these are listed below.

1. Students become acquainted with their scientific community and its surroundings.

2. They get an insight into vocational opportunities; for example, a trip to a weather station may lead one to become a meteorologist.

3. Opportunities are provided for collections and preparations for museum displays.

4. Desirable hobbies may develop from interests acquired on field trips.

5. The opportunity is afforded for students to observe many scientific relationships in their natural settings.

The success of a field trip depends very much on the preparation made in advance and the extent to which students are aware of the objectives and the follow-up activities to be pursued.

Preparation for a field trip involves the following considerations:

When?

Where?

Who?

Why?

How?

What to carry?

What to expect?

The follow-up may involve discussions, explanations, library work, readings, reports, classifications, and many other activities, depending upon the nature of the trip. It is suggested that every school system develop and maintain a list of places suitable for making field trips.

DEVELOPMENT OF SCIENTIFIC ATTITUDES

The personality factor called "attitude" is such a nebulous quality that it cannot be completely or satisfactorily defined in its entirety without illustrations and examples. Regardless of their indefinable quality, attitudes are recognized as being a vital influence in the learning of science. For this reason, they are listed separately from skills, understandings, and behaviors, in the list of objectives for learning junior high school science. (See Introduction—Objectives and Principles.) Also, they are treated as an introductory unit in the seventh grade level of the series of courses of study offered in this guide.

The goal for fostering the building of effective attitudes for science learning is to develop the personalities of science students so that they become as intellectually and emotionally mature as possible. They need to become persons who not only behave outwardly in desirable ways, but do so as the result of inward control based on self-understanding. Klausmeier suggests eight steps that teachers can consider in planning for attitude building, and which also may be used to facilitate the acquiring of correct attitudes by students. The following suggestions from Klausmeier have been adapted to science teaching:

(1) Scientific attitudes must be taught through precept, example, and experience with scientific processes and personnel.

(2) Clarity in meanings and values of the vocabulary used to describe scientific attitudes must be achieved.

(3) Models of desirable scientific attitudes, in the person of outstanding scientists, exemplary peers, parents, and the teacher, must be provided.

(4) Informative experience about attitude "objects", such as various situations that occur in the problem-solving process, should be provided.

(5) Pleasant emotional experiences should accompany the learning of attitudes.

(6) Appropriate contexts for practice and confirmation should be arranged.

(7) Group techniques in association with investigative and discovery methods should be used to facilitate understandings and acceptance.

(8) Deliberate cultivation of the desired attitude, with teacher-guided learning, should also be encouraged.

As mentor and model for the fostering of desirable scientific attitudes, the science teacher has prime responsibility. "Pupils cannot learn attitudes that their teachers don't have."[1] The classroom is not the place to teach scientific attitudes and principles, but rather a place to practice them. For this reason, it behooves the science teacher to add "attitudes" to his personal inventory evaluation.

Although every student of science will not become a scientist in the true sense of the word, all are scientists to some degree. The following list may prove helpful in describing and profiling a good scientist.

A good scientist is (1) observant, (2) curious, (3) intellectually honest, and (4) studious. He (5) reads intensively, (6) makes decisions, (7) imagines, (8) wonders, (9) thinks, (10) makes reports, (11) questions data, (12) draws conclusions, (13) keeps records, (14) uses illustrations, and (15) questions the validity of his conclusions.

EVALUATION OF STUDENT ACHIEVEMENT—Periodic evaluation is necessary in any learning procedure. Various attempts to evaluate should be made by *students* as well as by *teachers*. Any evaluation should be done in terms of the four groups of objectives—skills, understandings, attitudes, and behaviors. It may be formal or informal, and measured qualitatively or quantitatively. Since some achievements, in terms of the objectives, are more easily measured than others, a variety of techniques in evaluation must be employed. In any case, complete and discriminate judgments must be made in all aspects of evaluation before an honest decision can be made concerning a student's progress.

Various techniques can be employed *by the teacher* and *by the students* to measure progress. Some of these are *tests, check lists, rating scales*, and *descriptive critiques*. Where quantitative measurement is required, some value should be derived for the degree of attainment of goals other than those which are measurable by tests.

When tests are used, science teachers should strive to create tests which are learning devices as well as evaluation tools. They should apply diligent thought to the nature of their tests, to the validity and reliability of the test questions themselves. Tests which are factual in

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[1] Richard E. Haney, "The Development of Scientific Attitudes," The Science Teacher, XXXI (December, 1964), pp. 33-35.

nature often give a decided advantage to students who are capable of memorizing and interested in doing so. To reach every student and to achieve the objectives of science teaching, tests should contain questions and problems which call for knowledge, computations, analysis, synthesis of ideas, organization of facts, and evaluation.

Although it is possible for a teacher to be biased or non-objective in the oral evaluation of a student, it must be kept in mind that the teacher is an educated person with discreet ability to evaluate fairly a student who has been observed. Student evaluation has definite value, but in the final analysis the manner in which a student manipulates and improvises in laboratory and classroom situations is best evaluated by the teacher.

Part II. TOPICAL OUTLINE TO COURSE CONTENT

7th Grade — GENERAL SCIENCE

I. Introduction to General Science

  A. What Is Science?

  B. The Nature of Science
    1. Pure science (basic)
    2. Applied science (technology)
    3. Science disciplines
      a. Physics
      b. Chemistry
      c. Biology
      d. Earth and space science
      e. Mathematics
    4. Work of scientists
      a. Gathering evidence
      b. Measuring evidence
      c. Recording evidence
      d. Evaluating evidence

  C. How Science Is Related to Other Subject Matter Courses
    1. Mathematics — measuring and evaluation skills
    2. Social studies — social skills
    3. Language arts — communication skills (oral and written)

  D. Attitudes Toward Learning
    1. Everyday living as personal involvement in science
    2. Reasons for studying science
    3. Value of planned study
    4. Value of science study beyond the classroom

  E. Developing a Good Attitude Toward Science
    1. Intellectual honesty
    2. Awakening curiosity
    3. Orderly study in scope and depth

  F. Skills Which Help the Learning Process
    1. Organizing gathered evidence of science study (notebooks)
    2. Improving reading skills for science study
    3. Developing a working science vocabulary
    4. Organizing ideas in science study — outlining skills
    5. Developing the ability to take notes for various purposes
    6. Developing effective study methods for classroom performance
    7. Developing the ability to write scientific papers
    8. Developing the ability to measure completely and accurately
    9. Developing skills in critical thinking for problem solving

    (Note: The above skills are introduced and taught throughout the course where most timely for emphasis of study. Subsequent, continued application is required.)

II. Introduction to Earth Science

  A. The Earth
    1. Parts of Earth
      a. Atmosphere
        (1) State of matter
        (2) Layers

        - b. Hydrosphere
            - (1) State of matter
            - (2) Features
        - c. Lithosphere
            - (1) State of matter
            - (2) Features
        - d. Interrelationship of parts
    - 2. Layers of Solid Earth
        - a. Crust
            - (1) Divisions
                - (a) Continents
                - (b) Ocean floors
            - (2) Layers
                - (a) Arrangement
                - (b) Composition
                - (c) Functions
        - b. Mantle
        - c. Outer Core
        - d. Inner Core
    - 3. Rock Cycle
        - a. Classes of rock
        - b. Processes by which rocks are made
        - c. Distinguishing characteristics of classes
        - d. Kinds of rocks as examples of classes
    - 4. Minerals and ores
- B. Atmosphere
    - 1. Layers
    - 2. Water Cycle
        - a. Evaporation
        - b. Condensation
        - c. Precipitation
    - 3. Obtaining weather data
    - 4. Conserving water supply

III. Introduction to Physics

- A. Matter
    - 1. What is matter?
    - 2. States of matter
        - a. Behavior of molecules
        - b. Density as basis
    - 3. Properties of matter
        - a. Physical properties
            - (1) Definition
            - (2) Measurement
        - b. Chemical properties
    - 4. Changes in states of matter
- B. Energy and force
    - 1. Definitions
    - 2. Relationships
    - 3. Kinds of energy
        - a. Definitions
        - b. Examples
        - c. Conversion (basic principle)
    - 4. Sources of energy
        - a. Distinguishing characteristics between groups of sources
        - b. Specific sources as examples of groups

5. Forms of energy
    a. Mechanical
    b. Light
    c. Heat
    d. Chemical
    e. Electrical
    f. Solar
    g. Sound
    h. Magnetic
    i. Atomic and nuclear

    (the extent of development of the unit should depend upon the school's course of study for the sixth grade science and also the ninth grade science.)

C. Simple machines

1. Mechanical amplifier
2. Mechanical advantage
3. Balance
    a. Principle and definition
    b. Problems
4. Kinds of machines
5. Levers
6. Inclined planes
    a. Principle and definition
    b. Classes of inclined planes (Principles only)
        (1) Simple inclined plane
        (2) Double inclined plane (wedge)
        (3) Spiralled inclined plane (screw)
7. Efficiency (further option)
    a. Definition
    b. Problems
8. Power (further option)
    a. Definition
    b. Problems

D. Atoms and Molecules

1. Atoms
2. Diagram of simplest atom
3. Molecules

E. Basic Magnetism and Electricity

1. Magnetism
    a. Domains
    b. Poles
    c. Lines of force
    d. Magnetic fields
    e. Sources of magnetism
    f. Destruction of magnets
2. Electricity
    a. Definition
    b. Sources of electricity
    c. Definition of electrical circuit
        (1) Behavior of electrons
        (2) Parts of circuit
            (a) Source
            (b) Conductor
            (c) Device using electricity
    d. Open and closed circuits

e. Series and parallel circuits
(1) Physical differences
(2) Examples
f. Conduction of electricity
(1) Conductors—materials and substances
(2) Resistors—materials and substances
(3) Insulators—materials and substances
g. Evidence of electricity in human body
h. Safety measures in using electricity

F. Study of light (basic principles)
1. Solar spectrum
2. Refraction
3. Reflection

G. Sound (basic principles)
1. As a form of energy
2. Wave form principle
3. Characteristics

IV. Introduction to Chemistry

A. Review of Atomic and Molecular Structure
B. Table of Elements
C. Mixtures, Compounds and Chemical Changes
D. Significance of Chemistry in Other Areas of Science

V. Introduction to Biology

A. Basis of Life—The Cell (structure)

1. Typical cell
a. nucleus
b. cytoplasm
c. cell wall, membrane
d. chromatin bodies
e. vacuoles
2. Plant cells
a. structure
b. arrangement
c. examples
3. Animal cells
a. structure
b. arrangement
c. examples
d. comparison to plant cells

B. Cellular processes
1. osmosis
2. photosynthesis
3. respiration and transpiration

C. Growth and Development of Cells
1. Means of growth
a. budding
b. division (basic principle only)
2. Regeneration
3. Ascending arrangement in organism (determining function)
a. tissues
b. organs

        - c. systems
        - d. organism
    - 4. Sequence and rates of growth for boys and girls
- D. Living Societies—Plants and Animals
    - 1. Kingdoms
    - 2. Factors affecting balance of nature

VI. The Science of Soil and Water Conservation (Optional Unit)

(Kit from Department of Agriculture, Mississippi Office of Soil and Water Conservation)

- A. Our Lives Depend on Soil and Water
- B. What is Soil?
- C. Soil Erosion
- D. Good Land Use Conserves Soil
- E. Hugh Bennett—Father of Soil Conservation
- F. Soil Conservation Districts
- G. How Mississippi Farmers Plan
- H. What Will Our Future Needs Be?
- I. Team Work in Conservation
- J. You Can Study Your Own Country

8th Grade—EARTH AND SPACE SCIENCE; LIFE SCIENCE

First Semester—EARTH AND SPACE SCIENCE

I. The Earth
  - A. Location
  - B. Size
  - C. Shape
  - D. Divisions
    - 1. Lithosphere
      - a. Crust
        - (1) Internal forces
        - (2) External forces
      - b. Land forms
        - (1) Built by earth movements
        - (2) Formed by destructive processes
      - c. Theories of movements
        - (1) Isostasy
        - (2) Contraction
        - (3) Convection
        - (4) Continental drift
    - 2. Hydrosphere
      - a. Oceans
        - (1) Currents
        - (2) Minerals
        - (3) Life
      - b. Other ground water
        - (1) Storage
        - (2) Movement
      - c. Hydrology
        - (1) Chemical processes
        - (2) Features in earth
    - 3. Atmosphere
      - a. Physical characteristics
        - (1) Pressure
        - (2) Temperature
        - (3) Humidity
      - b. Air masses
        - (1) Front
        - (2) Winds
        - (3) Storms
        - (4) Weather forecasting
      - c. Climate
  - E. Age
    - 1. Geological Time
      - a. Cryptazoic Eon
      - b. Phanerozoic Eon
        - (1) Palezoic Era
        - (2) Mesozoic Era
        - (3) Cenozoic Era

II. Solar System

- A. Theories of Origin
- B. Planets
  - 1. Comparative Sizes and positions
  - 2. Relative distances from the sun
    - a. Astronomical units
    - b. Bode's Law
  - 3. Natural satellites
    - a. Phases
    - b. Eclipses
    - c. Tides
  - 4. Gravitational attraction
  - 5. Revolutionary and rotational movement
    - a. Units of time
    - b. Time belts
    - c. International Date Line
    - d. Calendar
    - e. Seasons

III. The Sun — Our Star

- A. Size
- B. Composition
- C. Temperature
- D. Energy Source
- E. Surface Features

IV. The Stars

- A. Composition
- B. Size
- C. Magnitude
- D. Temperature and Color
- E. Location and Distance
- F. Motion and Effects
- G. Constellations
- H. Galaxies
- I. Other star-like bodies
  - 1. Comets
  - 2. Meteors
    - a. Composition
    - b. Origin
  - 3. Asteroids
    - a. Composition
    - b. Origin
  - 4. Nebulae

V. Space Exploration

- A. Satellites and rockets
  - 1. Types of rockets
  - 2. Launching rockets
  - 3. Tracking rockets
  - 4. Rocketry problems
    (Example of development of topic by fluid inquiry)
  - 5. Gravity

B. Space Problems for Man
  1. Weightlessness
  2. Temperature and pressure
  3. Food
  4. Radiation

C. Survey of Artificial Satellites (Optional)
  1. Communications
  2. Weather
  3. Observation

Second Semester — LIFE SCIENCE

I. Living Things

A. The Nature of Living Things
  1. Physical Basis of Life
    a. Cells
    b. Protoplasm
    c. Carbohydrates as source of energy
    (Note: This portion of the unit provides an introduction to chemical formulas in biology.)
  2. Typical Cells
  3. Life Functions
    a. Food getting and use
    b. Oxygen getting and use
    c. Movement
    d. Growth
    e. Reaction to stimuli
    f. Reproduction
  4. Biographies
    a. New knowledge and discoveries built on work of others
    b. Development of biology related to development in other areas of scientific knowledge
  5. Microscope
    a. Use
    b. Care

B. Life Functions of Animals
  1. Kinds of life functions
  (Study of selected characteristic animals)
  2. Specialization of body parts
  (Serves as basis for introduction to classification)
  3. Adjustment to environment

C. Life Functions of Flowering Plants
  1. Roots
  2. Stems
  3. Leaves
  4. Food-making
  5. Seeds
  6. Tropisms
  7. Leaf—special adaptation for photosynthesis
  8. Flowers

II. Interdependency of Plants and Animals

A. The Oxygen Cycle
B. Photosynthesis
C. The "Food Chain"

III. Classification of Living Things

- A. Classification in General
  1. Planned system
  2. Homologous structure of animals
  3. Major divisions and sub-divisions
  4. Bases for differentiation
- B. Divisions of Plant Kingdom
  1. Four major phyla
  2. Distinctions
- C. Classification of Plants
  (Laboratory study)
- D. Divisions of Animal Kingdom
  1. Major divisions and sub-divisions
  2. Studies of selected invertebrate phyla
  3. Studies of vertebrate classes

IV. Genetics

- A. Heredity and Characteristics
- B. Components of Reproductive Cells
- C. Cell Division (basic understanding)
  - a. Mitosis
  - b. Meiosis

V. Human Biology

- A. Anatomy
- B. Physiology
  1. Basic processes of selected systems
  2. Enzymes
  3. Vitamins
  4. Cancer
- C. Metabolism
  1. Energy for cells
  2. Cell oxidation
  3. Calories

VI. Conquest of Disease

- A. History of Progress
  1. Germ theory
  2. Selected biographies
  3. Recent discoveries
  4. Extension of life span
- B. Diseases of Man
  1. Pathological diagnosis
  2. Control, prevention
     - a. Serums
     - b. Vaccines
     - c. Immunization programs
  3. Community and personal health
     - a. Sanitation
     - b. Water purification

        - c. Water pollution
        - d. Public Health Department
        - e. Harmful use of narcotics, alcohol, and tobacco

VII. Areas of Hobbies and Vocations

- A. Birds
- B. Fish
- C. Insects
- D. Trees
- E. Flowering Shrubs
- F. Evergreens
- G. Plant Culture
- H. Wild Flowers
- I. Lawn Grasses

9th Grade — INTRODUCTION TO PHYSICAL SCIENCE

I. Introduction—Physical Science and Its Areas
  A. Unification of Physical Sciences
  B. Basic Assumptions in Scientific Pursuits

II. Relationship of Mathematics to Physics and Chemistry
  A. Comparison of English and Metric Systems
    1. Metric system as universal scientific system in calculations
    2. Study of prefixes and basic units
    3. Use of capitals in symbols
    4. Internationally accepted notations
    5. Advantages of metric system over English
  B. Basic and Derived Units
  C. Scientific Notations and Significant Figures and Approximations
    1. Scientific notations
    2. Significant figures and approximations
      a. Approximate measurements
      b. Precision instruments
  D. Conversion of Units
  E. Use of Slide Rule (Skill Optional)

III. Organization of Matter
  A. Identification and properties
    1. Basic properties
      a. Mass
      b. Volume
      c. Density
    2. Specific properties
      a. Physical
      b. Chemical
  B. States of Matter
    1. Kinetic-molecular theory
    2. Solids, liquids, gases, and plasma
      a. General characteristics
      b. Mass inertia-definitions and relationships
  C. Classification of Matter
    1. Heterogenous mixtures and alloys
       (To acquaint pupil with the behavior of materials)
    2. Homogenous Substances
      a. Solutions
        (1) Identifying characteristics
        (2) Identifying elements and compounds
      b. Pure substances
        (1) Elements
        (2) Compounds
        (3) Use of symbols and formulas

IV. **Fluids**

- A. Density and Specific Gravity
  - 1. Definition of density
  - 2. Definition of specific gravity
  - 3. Numerical relationship to metric system
- B. Pressure
- C. Buoyancy
  - 1. Archimedes' principle
  - 2. Effect of downward pull of gravity
- D. Hydraulics
- E. Fluids (liquid or gas) in Motion

V. **Force and Motion**

- A. Gravitation and Gravity
  - 1. Universal law of gravitation
  - 2. Inverse square law
  - 3. Advantages and disadvantages in gravity
- B. Velocity and Acceleration
  - 1. Definition of velocity
  - 2. Definition of acceleration
- C. Newton's Laws
  - 1. Inertia
  - 2. Force-mass-acceleration
  - 3. Action and reaction

VI. **Energy, Work, and Power**

- A. Energy
  - 1. Manifestation
  - 2. Conversion
  - 3. Constancy
  - 4. Law of Conservation of Matter
- B. Work
  - 1. Definition
  - 2. Forms of resistance that oppose work
    - a. Inertia
    - b. Gravity
    - c. Friction
  - 3. Work of simple machines (See 7th grade unit on physics)
    - a. Levers
      - (1) First class
      - (2) Second class
      - (3) Third class
    - b. Pulleys
    - c. Inclined planes
    - d. Wheels and axles
  - 4. Mechanical advantage of machines
    - a. Theoretical
    - b. Actual
  - 5. Efficiency
  - 6. Power

VII. Heat

- A. Kinetic Theory (including gas laws)
  - 1. Relationship of radiant energy to molecular activity
  - 2. Movement of thermal energy
- B. Specific Heat and Thermometry
  - 1. Thermal energy in relation to weight
  - 2. Use of thermometers
  - 3. Specific heat standard of water
- C. Calorimetry and Heat Transfer
  - 1. Methods of heat transfer
    - a. Conduction
    - b. Convection
    - c. Radiation
  - 2. Conversion of BTU and calorie measurement
- D. Mechanical Equivalent of Heat
  - 1. Mechanical equivalent of heat-ratio of work done to heat produced
  - 2. Machines operated because of heat principles

VIII. Introduction to Chemistry: A Few Basic Concepts

(See 7th grade section for background review)

- A. Atomic Structure
  - 1. Proton
  - 2. Electron
  - 3. Neutron
- B. Terms
  - 1. Atomic number
  - 2. Atomic weight
  - 3. Isotope
  - 4. Periods
  - 5. Groups (periodic table)
  - 6. Others
- C. Electron Configuration
- D. Valence (oxidation number)
  - 1. Definition
  - 2. Examples

IX. Inorganic Compounds

- A. Acids
- B. Bases
- C. Salts
- D. Oxides

X. Chemical Bonding

- A. Definition
- B. Types of Bonds
  - 1. Covalent
    - (a) Polar
    - (b) Nonpolar
    - (c) Coordinate covalent
  - 2. Electrovalent
  - 3. Others

XI. Conductivity of Solutions
  A. Electrolytes
  B. Nonelectrolytes

XII. A Classification of the Elements

XIII. Chemical Reactions

  A. Atomic Weight
  B. Formula Weight
  C. Combining Ratios
  D. Evidences of Chemical Reactions
    1. Noticeable energy changes
    2. Noticeable physical changes
    3. Endothermic reactions
    4. Exothermic reactions
  E. Some Types of Chemical Reactions
    1. Combination reactions
    2. Decomposition reactions
    3. So-called displacement reactions
    4. Oxidation-reduction reactions
  F. Effect of Catalysts on Reactions

XIV. Electricity at Rest

  A. Nature of Electric Charge
  B. Charged Bodies
    1. Reason for charged bodies
    2. Danger of excessive static charges
  C. Conductors and Insulators
    1. Definitions
    2. Determinations
  D. Electrical Attraction and Repulsion
    1. Electroscope
    2. Van de Graff generator electric whirl
  E. Electrical Fields
    1. Existence
    2. Uses

XV. Magnetism

  A. Nature of Magnetism
  B. Terrestrial Magnetism
  C. Magnetic Attraction and Repulsion
  D. Magnetic Fields

XVI. Electricity in Motion

  A. Chemical Energy
    1. Sources
    2. Electro-chemistry
  B. Current and Charge
    1. Static electricity as compared to current electricity
    2. Electric current

        3. Measurements of current
        4. Electromagnetic waves
    - C. Voltage
        1. Definition
        2. Measurement
    - D. Resistance
        1. Definition
        2. Measurement
    - E. Ohm's Law
    - F. Series and Parallel Circuits
        1. Basic electrical symbols
        2. Laws of series and parallel circuits
        3. Measurement of resistances in a circuit

XVII. Electromagnetism

- A. Producing Magnetic Fields—Electromagnets
- B. Production of Electric Current
    1. Changing magnetic fields
    2. Transformers
- C. Alternating Current
    1. Generator
        - a. Principles
        - b. Principal parts
    2. Motor
        - a. Construction
        - b. Uses

XVIII. Applications of Electrical Energy

- A. Mechanical Energy
    1. Transfer of electrical energy
    2. Determination of mechanical energy
- B. Heat, from Electrical Energy
    1. Conversion of electrical energy into heat energy
        - a. Cause of heat
        - b. Commercial heating elements
        - c. Measurement of heat released proportional to resistance, current, time
        - d. Measurement of heat released proportional to diameter and length of wire
- C. Conversion of Electricity to Light
    1. Production of light
    2. Lamps
- D. Chemical Effect of Electrical Current
    1. Electrolysis
    2. Electroplating

XIX. Sound

- A. Definition
- B. Producing Sound
- C. Transmitting Media of Sound

- D. Aspects of Sound
  - 1. Identification of aspects
  - 2. Transverse waves
  - 3. Longitudinal waves
  - 4. Modulation of waves
- E. Acoustics
  - 1. Intensity of sound and inverse-square law
  - 2. Reflected sound waves
  - 3. Materials
- F. Music and Noise
  - 1. Distinction
  - 2. Uniformity of amplitude
  - 3. Uniformity of frequency
- G. Musical Instruments
  - 1. Source of sound
  - 2. Principles of sound

XX. Light

- A. Definition
  - 1. Electro-magnetic radiation
  - 2. Wave lengths
  - 3. Theory that light exerts pressure
- B. Nature of Light
  - 1. Wave theory
  - 2. Corpuscular theory
- C. Source
  - 1. As form of radiant energy
  - 2. Source of electrons
  - 3. Relativity of speed to source
- D. Intensity of Illumination and Brightness
  - 1. Light intensity
  - 2. Strength of light or brightness
    - a. Candle power
    - b. Relation between foot candles and candle power
- E. Refraction and Reflection
  - 1. Variation with refracting media
    - a. Plane mirror
    - b. Concave mirrors
    - c. Convex mirrors
  - 2. Refractive index
- F. Visible and Near-visible Portions of the Spectrum
  - 1. Function of rods and cones of retina
  - 2. Visible light portion of spectrum
  - 3. Infrared rays
  - 4. Ultraviolet rays
  - 5. X-rays
- G. Invisible Electro-magnetic Radiation
  - 1. Discovery and uses of
    - a. Radio
    - b. Radar
    - c. Cosmic rays

    - d. Gamma rays
    - e. Micro waves
  - 2. Special instruments of detection

XXI. Radio and Television

- A. Radio
  - 1. Principles based on understanding of magnetism and electricity
  - 2. Development of instruments preceding radio
  - 3. Radio circuits
  - 4. Radio waves
    - a. Relationship between light and electromagnetism
    - b. Predicted by Maxwell
    - c. Maxwell's predictions confirmed by other scientists
  - 5. Vacuum tube
  - 6. How it works
  - 7. Historic discoveries in development of radio
- B. Television
  - 1. Photoelectric cells
  - 2. Iconoscope tube
  - 3. Kinescope tube
  - 4. Color transmission

XXII. Nuclear Science

- A. Nuclear Particles and Radioactivity
  - 1. Alpha particle
  - 2. Beta particle
  - 3. Gamma rays
  - 4. Sources of radiation
  - 5. Geiger counter
- B. Isotopes
  - 1. Definition
  - 2. Radioactive isotopes
- C. The Release of Nuclear Energy
  - 1. Terminology
    - a. Fission
      - (1) Transmutation
      - (2) Critical mass
      - (3) "Breeder" reactor
      - (4) Accelerator
      - (5) MEV (Million Electron Volt)
    - b. Fusion
      - (1) Principle
      - (2) Increase of energy in fusion explosions compared with fission explosions
      - (3) Limits of control for peaceful uses
  - 2. Instruments
    - a. Geiger counter
    - b. Electroscope
    - c. Dosimeter
    - d. Scintillation counter
    - e. Film badge
    - f. Cloud chamber
  - 3. Civil Defense

- D. Peacetime Applications of Nuclear Energy
  - 1. Applications in various fields
    - a. Industry
    - b. Agriculture
    - c. Medicine
    - d. Space exploration
    - e. Research
  - 2. Nuclear Reactor

XXIII. Career Opportunities

- A. Manpower
- B. Literacy
- C. Leadership

PART III—THE COURSES OF STUDY

UNIT I—7th Grade

GENERAL SCIENCE

Unit I. Introduction to General Science

Topics	*Understandings*	*Suggested Activities and Materials*
A. What is Science?	There is no single answer to the question, "What is science?" Science is both organized knowledge and a process. Through science man attempts to interpret, control, and change his environment. This process calls for continuous observation, exploration, questioning, measuring, hypothesizing, and testing. Science calls for caution, the maintenance of doubt, suspended judgment. It emphasizes reason, logic, and the freedom to think. Science is all of this and more.	Get thoroughly acquainted with the organization of textbook, such as table of contents, glossary, index, study helps, activities, etc. Using the table of contents of the textbook and other class sets of books, correlate their units and chapters to the units of study in this course of study outline. Explain the teacher's standard notebook procedure. Using course of study outline, give overview of this course.
B. The Nature of Science	Scientists have divided their work into basic and applied science and have further delineated these subdivisions. These subdivisions, or areas in general, are physics, chemistry, biology, earth and space science, and mathematics.	Discuss overlapping and interrelationship of various divisions of science. Report on scientists: past, present, and future.
	The work of the scientist is based on evidence obtained by careful, thorough observation and measurement; and by accurate, complete, written records, free of bias and supposition.	Observe the surroundings in the classroom as well as the outside with the comparison of living and nonliving matter, illustrating the distinction between physical and biological sciences. Try to

Topics	*Understandings*	*Suggested Activities*
(Unit I, continued)	Chemically, *oxidation is any process in which electrons are lost.* One common form of oxidation is the process by which elements combine with oxygen. Burning is an example of this kind of oxidation. For a long time, scientists had the wrong idea about the nature of burning. One theory, popular during the 18th Century, was the phlogiston theory. Combustible, materials were thought to be rich in a substance called phlogiston. We are indebted to Lavoisier, a French scientist, for the correct explanation of burning.	help students develop the ability to recognize the usual and look for the unusual. Discuss how scientists of different areas and nationalities work together; for example, IGY studies, International Standards, Biology Year, etc. Give each student a small candle. Have students write down everything that they can observe about the candle. Compare and discuss observations N.ext, let student light the candle, observe and than compare observations.
C. How Science Is Related to Other Subject Matter Courses.	The scientist, like any other professional person, must develop certain skills. He must know his field of work, use mathematics effectively, be able to communicate with others in both oral and written forms.	FILM - The Nature of Burning. Have class consider how skill in each of the subject matter courses which they will study in school will help them in science.
D. Attitudes Toward Learning.	Science has altered the daily life of every man, woman and child more than any other endeavor since the existence of modern man. Every person every day is a consumer. Many people are involved in the production and distribution of the things of science. Others are teachers or students of science. To escape involvement in science is neither possible nor desirable.	Discussions on: a. Who are scientists? b. How and why the average person is involved in science. c. What do we learn by studying science? d. Why study science? (national, state, and local welfare; security and economic development.)

Topics	*Understandings*	*Suggested Activities*
(Unit I, continued)		When and how to study science. (Value of planned study) Where to study. (At home, at school, at work, at play.) All learning is not done in the classroom with formal assignments.
E. Developing a Good Attitude Toward Science	Science is a human pursuit which requires intellectual honesty. It is born of curiosity, fed by stimulating challenges. It is an orderly study of the smallest particle and the total universe, of which man himself is a part.	Use of library. (Ask librarian's help.) Field trip. Discussion of facts, fallacies, superstitions. Compare life in the average home of today with that of grandparents' or compare trip across country today with that of 100 years ago.
F. Skills Which Help The Learning Process	Achievement in science is increased by the development of many study skills. Timely instruction, application, and practice will help to provide a firm foundation for the student. Among the skills which are most useful are: How to organize notebooks How to read a science book How to increase one's vocabulary How to outline (organize ideas) How to take notes How to study for a test How to write a report How to measure How to solve a problem	Textbook chapters which do not correlate easily with the course of study may be used effectively for learning and practicing reading skills. Chapters of a historical nature are easiest to use and also give foundation for science study and for previous discussions in this unit. (See teaching aids at end of unit for notes on reading skills.) FILM - How to Study. Coronet. Consult a scientific dictionary for meaning and pronunciations of scientific terms. Correct spelling should be practiced. (See references a & b)

References:
(a.) *Scientific Dictionary.* Compton Encyclopedia Company.
(b.) *Scientific Dictionary.* Van Nostrand.

Topics	*Understandings*	*Suggested Activities*
(Unit I, continued)		**a. Review Roman numerals as foundation for outline writing.**
		b. Provide class with basic rules for outline construction.
		c. Practice making simple outlines of reading assignments. (This activity effectively follows that of reading skills.)
		FILMS by Coronet: How To Take Notes, How To Take a Test, How to Judge Facts. Also see catalogues of other companies, such as Encyclopedia Britannica, which make instructional films.
		Provide the class with an organized method and standards for doing written reports. (See handbook section.)
	This three-year plan provides for detailed study of the metric system in the ninth grade. However, the basic units (gram, kilogram, centimeter, meter, milliliter, liter) must be thoroughly understood by the seventh grade student to insure his competence in procedures involving measurement.	**Scientific measurements are based on the metric system. Study this system and provide experiences for its use.**
		For skill in how to state and solve a problem, see the "Hypothetical Classroom Situation" with the chemistry unit. This is based on the supplementary material to this unit.

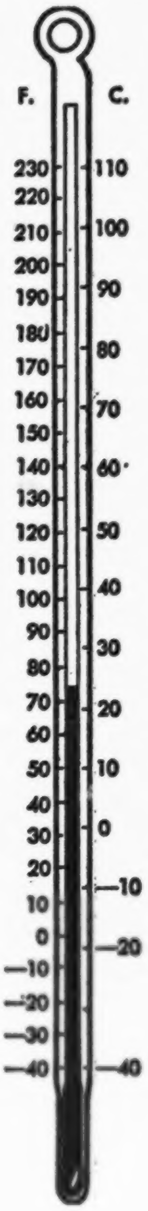
For Use As A Teaching Aid—Unit I

SEVENTH GRADE COURSE OF STUDY—GENERAL SCIENCE

	Correlation with text			Other Mater.	References
	Units	Chapters	pages		
I. Introduction to General Science					
A. What Is Science?					
B. The Nature of Science					
C. How Science Is Related to Other Subject Matter Courses					
D. Attitudes Toward Learning					
E. Developing a Good Attitude Toward Learning Science					
F. Skills Which Help the Learning Process					
G. Extended Science Activities					
II. Introduction to Earth Science					
A. The Earth					
B. The Atmosphere					
III. Introduction to Physics					
A. Matter					
B. Energy					
C. Simple Machines (optional)					
D. Structure of Atoms & Molecules					
E. Basic Magnetism & Electricity					
F. Study of Light					
G. Study of Sound					
IV. Introduction to Chemistry					
A. Review of Atomic & Molecular Structure					
B. Periodic Table of Elements					
C. Mixtures, Compounds, and Chemical Changes					
D. Significance of Chemistry in Other Areas of Science					
V. Introduction to Biology					
A. Basis of Life - The Cell					
B. Cellular Processes					
C. Growth and Development					
D. Living Societies-Plants & Animals					
VI. The Science of Soil and Water Conservation					
A. Our Lives Depend on Soil & Water					
B. What Is Soil?					
C. Soil Erosion					
D. Good Land User Conserves Soil					
E. Hugh Bennett-Father of Soil Conser.					
F. Soil Conservation Districts					
G. How Mississippi Farmers Plan					
H. What Will Our Future Needs Be?					
I. Team Work in Conservation					
J. You Can Study Your Own County					
Portions of text not specifically correlated to Course of Study Outline (for enrichment)):					

Teaching Aid—Unit I

Unit I - Earth and Space Science - Topic: Atmosphere, Temperature (Lab lesson)



The two scales most commonly used in measuring temperature are centigrade and Fahrenheit. (Find out what other scales are used and why). Centigrade is the scale preferred by most of our scientists. (Can you determine why this is true?

Examine a centigrade and a Fahrenheit thermometer, noticing the difference in the spacing of divisions. Place each thermometer in a 250 ml. beaker of water. Heat each to boiling:

C boiling point______________

F boiling point______________

Place 250 ml beaker of water in a solution of ice and salt. Check the freezing point with both thermometers.

C freezing point______________

F freezing point______________

Imagine the degree on the two thermometers to be steps. The distance is the same but the steps are not the same length. We can compare the two thermometers by saying that one has short steps and the other has long steps.

(a) Which thermometer has the long steps?______________

How many times as long are they as the short steps?______________

(b) Which thermometer has the short steps?______________

The short steps are only______________as long as the long steps. (Give fraction.)

(c) One degree on the centigrade scale is equal to______________

degrees on the Fahrenheit scale.______________

(d) One degree on the Fahrenheit scale is equal to______________ degree on the centigrade scale.

Referring to the above, explain why these two formulas are correct for converting temp. from one scale to another.

$$F = \frac{9}{5}c + 32 \qquad c = \frac{5}{9}(F-32)$$

Try these problems:

1. What will 10 degrees on the centigrade equal on the F thermometer?
2. If the temperature drops from boiling to 90 degrees C what would it drop to on F?
3. When it is O°F, how many degrees below freezing is it on this same scale?
4. What is the ideal indoor temperature in C° if it is considered to be 68° on the F scale?
5. Alcohol thermometers are used in polar regions where temperature is below freezing point on Mercury. What is the freezing point of mercury in F°? in C°?

Unit II—7th Grade

Unit II - Introduction to Earth Science

Topics	*Understandings*	*Suggested Activities*
A. The Earth 1. Parts	For purposes of reference and study the earth is divided into the following areas: the crust, mantle, outer core, and inner core. The earth's crust is further divided into parts known as continents and ocean floors.	See teaching aids - Cross Section of Globe. Library reports on the earth and what it is like. Film-The Earth-The Changing Surface. Film List, item 59.
2. Layers	The continents are sub-divided into topsoil, subsoil, and bedrock. Life is supported by the relatively thin layer known as soil.	Draw and label a cross-section of the earth. Make a model of a cross-section of the earth's crust. See teaching aids - Rock Cycle
3. Rock cycle	The solid part of earth, known as the lithosphere, is composed of minerals which in various combinations make up the rocks of the earth. The rocks may be classified according to the processes by which they are formed and by distinguishing characteristics. The ever-changing process by which rocks and minerals are built and torn down is sometimes referred to as the "rock cycle." (evolution)	Demonstration on sedimentation: Shake a mixture of dirt in one quart of water. Allow it to sit undisturbed. Note the rate by which varying sizes of particles settle. Note the characteristic layers formed by the process. Relate what is learned here to the cross-section of earth's crust. Demonstration on crystallization: a. Place a few grams of powdered sulfur (Flowers of Sulfur, which is obtained at any drugstore and some groceries) on a glass slide. Heat

Topics

A. The Earth (Continued)

Understandings

Suggested Activities

over a candle. Allow to cool. Wipe off carbon deposit. Note the formation of crystals. If polarized lenses are available, observe the crystallization process through them.

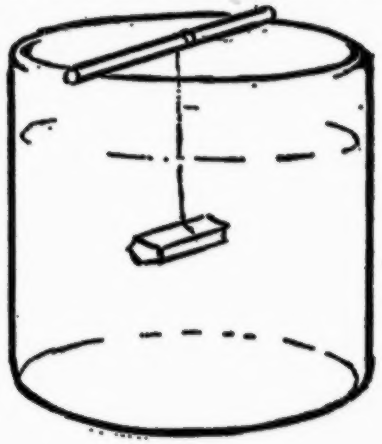
b. Melt moth balls (naphthalene) in a test tube and pour on glass plate.

Project: Growing crystals from solutions—salt, sugar, (copper sulfate) $CuSO_4$, alum, etc.

Saturate about fifty mls. of water with saltpeter (KNO_3). Allow to cool solwly to room temperature.

Build models of crystals using tooth picks and gum drops.

HOW TO GROW CRYSTALS



Topics	*Understandings*	*Suggested Activities*
Unit II - Continued		
3. Rock Cycle (continued)	Rocks are of three general classes: igneous, sedimentary and metamorphic. Igneous rocks (granite, pumice, lava rock, basalt and others) are formed in heated interior parts of the earth. Sedimentary rocks (limestone, sandstone, and shale) are formed in underwater areas through sedimentation. Metamorphic rocks (marble, slate, gneiss, or schist) have been formed by internal stresses through heat and pressure.	Make a saturated solution of salt, Copper sulfate, Rochelle salts or any other chemical salt you may have. Do this by stirring the chemical in hot water until no more will dissolve. Let the solution cool and suspend a thread in it. Small crystals will come out of the solution. If you can control the temperature and rate of evaporation so it takes place very slowly and at a constant temperature, you can grow large and perfect crystals. Use a small perfect crystal for a seed crystal and permit evaporation to take place slowly. Grow silicate gardens. These are available from variety shops and hobby shops, or, purchase water glass (Na_2SiO_3) at about $1.50/gal. Mix one part water glass with four parts water. Drop in various crystalline materials. Chlorides of various metals are good, too. Filmstrip: How Crystals Are Formed. See Film list, item 59. For extended activities: a. Let interested students study crystal growing. One source of instructions. See reference a.

References:
(a.) *Geology and Earth Science Source Book*. p. 23.

Topics	*Understandings*	*Suggested Activities*
(Unit II - continued) 3. Rock Cycle (continued)	Rock forming minerals may be identified by hardness, (scale of 1-10), specific gravity, (cleavage), streak, color. luster, or chemical tests.	b. Study differences in crystal shapes and sizes. Place a one-inch sheet of styrofoam between two planks. With a hammer, vise, or other means causing great pressures, press the styrofoam as flat as possible. This demonstrates the process by which metamorphic rocks are made. (A damp sponge allowed to dry under pressure may also be used.) Film: Finding Out About Rocks. Study samples of rocks to determine which of the three major classes to which they belong. Note the distinguishing characteristics in each. (Suggested samples: limestone, marble, quartz, sand, sandstone, shale, granite, gneiss, slate, etc.) Film: Rocks and Minerals, item 59. Obtain an inexpensive rock kit from the Mississippi Geologic Survey, 2525 Northwest Street, Jackson (or other source). Use it for the following activities. Tests for physical properties of rock forming minerals: (1) Test for hardness.

Topics	*Understandings*	*Suggested Activities*
Unit II - continued		(2) Test for specific gravity. (Weigh in air and water or weigh displaced water) (3) Determine cleavage or fracture. (4) Determine streak by rubbing on the streak plate. (5) Determine luster. Chemical tests: (1) Apply a dilute solution of hydrochloric acid (or vinegar) to a suspected limestone rock. If it fizzes or bubbles, it has calcium carbonate. Note the odor. $CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$ (2) Place a few shells in a jar. Cover with a dilute solution of hydrochloric acid (or strong vinegar.) Allow to set. Note the gradual dissolving of shells. Relate to formation of limestone.
4. Minerals and ores	Mississippi has vast mineral resources, many of which are of great economic importance. Examples are: limestone; gravel; sand; petroleum.	Study the mineral kit. Learn the location in Mississippi of various minerals and their economic importance. Bulletins at the Mississippi Geological Survey are available at low cost. A quarry or exposed earth cut in your area may be visited where fossils are collected. (Examples: shark's teeth near Jackson and south of Meridian; petrified wood at Flora and

Topics	*Understandings*	*Suggested Activities*
(Unit II, continued)		in the Wolf River area of Harrison County, loess in the delta region.) Gather samples of the three classes of rocks from gravel. Discuss what gravel is, why it is rounded, possibility of origins, uses. Become acquainted with a member of the Mississippi Gem and Mineral Society. Exhibits of this society may be visited. Make individual rock collections. Make posters or exhibits on as many different uses of rocks and minerals as can be found. Include information on the conservation of rocks and minerals. Film: Rocks, Minerals, and Soil. See film list, item 59. For advanced students or advanced study: Teacher might work out problem for specific gravity. See Reference a.
B. The Atmosphere 1. Layers	Man lives in an envelope of gases called an atmosphere. For references of study, the atmosphere is divided into layers: troposphere; stratosphere; chemosphere; ionosphere, exosphere. Each of these layers has a special characteris-	Learn the names of the gases in the atmosphere and the percentage of each. Film: Ocean of Air, item 30. Make posters or relief maps showing

References:
(a.) *Science For Progress.* p. 306.

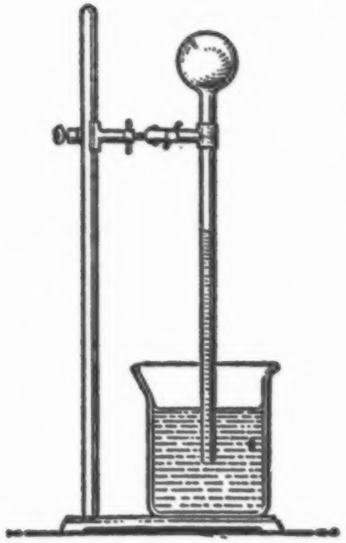
Topics	*Understandings*	*Suggested Activities*
(Unit II, continued)	tic. Beyond the ionosphere is the exosphere which is outer space.	layers of atmosphere.
	All weather takes place in the troposphere. Continual processes of evaporation, condensation, and precipitation, like other forms of weather, are caused by the uneven heating of the earth's surface by the sun and the turning of the earth on its axis.	Make posters and exhibits (of cotton) showing the four basic cloud forms (cumulus, nimbus, stratus, cirrus). Compare their average heights above earth. Study the "water cycle." Film: "Water Cycle," list item No. 31. Film: "Water and What It Does", film list item No. 32.
2. Water Cycle		Demonstrate the water cycle processes. Bring a pan of water to boiling. Hold over it a bowl or pan filled with ice cubes. The steam demonstrates *evaporation;* its collection on the bottom of the cold bowl demonstrates *condensation precipitation* is seen when the drops collect and fall as "rain." Experiment: Making dew and recording the dew point. Record the room temperature. Then place some water and ice cubes in a shiny tin can. Be sure that the outside of the can is dry. Put a thermometer in the can and read the temperature. Stir the mixture slowly, watching for moisture to condense on the can. When

Topics	*Understandings*	*Suggested Activities*
(Unit II, continued)		moisture condenses, read the temperature of the mixture at once. This is the dew point (the temperature at which condensation occurs). Now compare the dew point with the actual room temperature and note the difference. How much cooling would have to occur to produce condensation? It is advisable to repeat this experiment to check the accuracy of your results. A more accurate determination may be made by heating the ice water and recording the temperature when moisture evaporates. Take the average of the two temperatures.
3. Obtaining Weather Data	The continuity of life on earth is greatly affected by the return of water making elements through processes and features called the water cycle, water table, and watershed. Scientists have extended their senses by developing instruments to measure and predict changes in these elements.	Study the "water table." Discuss its importance to the availability of water in various areas. Understand the basic principles of the artesian system and the difference between deep and shallow wells, highlighting the purity of water from each. Study the features of a "watershed." Relate to the river systems nationwide and to the local drainage systems. An interesting model of a watershed can be made. Make a home-made weather station and record weather data daily from barometer, thermometer, rain guage and humidity guage. Make a wall chart for recording this data. Graphs of daily changes may also be made.

Topics

(Unit II, continued)

Understandings



AIR THERMOMETER

Why is it not practical?

Suggested Activities

Make a wind vane by use of a feather, cork, glass tube for bearing, finishing nail, and wood block.

Make a liquid thermometer from flask, one hole stopper, and glass tube. Heat liquid and observe level.

An air thermometer may be made by use of the same equipment above, plus a beaker. The flask is inverted with water in beaker and in the tube. Heating the bulb of the flask forces liquid down the tube. This may be calibrated.

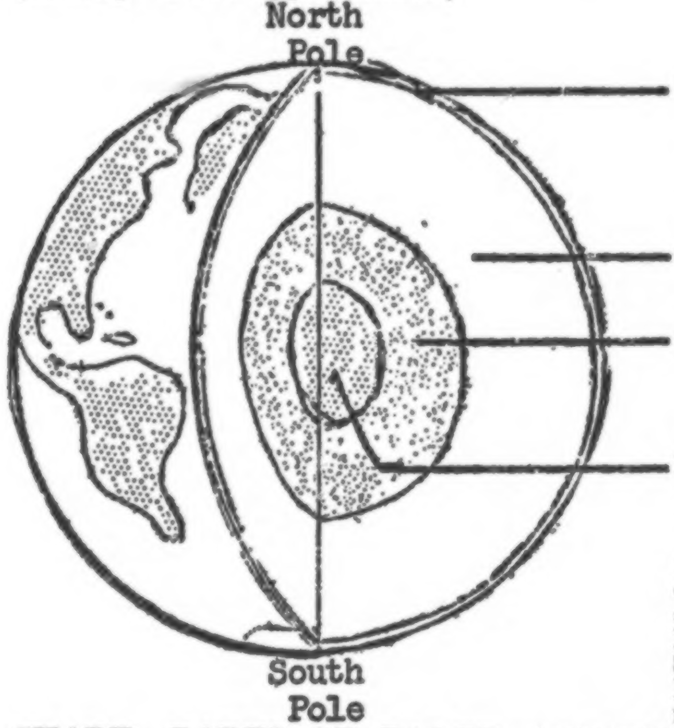
Make a mercury barometer by use of a tube closed at one end, mercury and a beaker or bowl. Tube should be at least 34 inches long. With the help of a small funnel and a piece of rubber tubing, fill the tube completely with mercury. Now, hold your finger over the open end to prevent the very heavy mercury from running out. (It is best to protect your finger with a piece of plastic or paper, as mercury is very poisonous.) Invert the tube into a bowl of mercury, being careful not to remove your finger until the end is under the surface. When you remove your finger, you will notice that the level of the mercury in the tube will drop a little. This space is now a vacuum.

Topics	*Undersandings*	*Suggested Activities*
(Unit II, continued)		Make a simple aneroid barometer. Cut the dome-shaped end of a rubber balloon from its neck and snap over the top of a milk bottle or similar container. Attach a broom straw or paper drinking straw to the stretched rubber with a drop of airplane glue or rubber cement. Place the bottle against a free-standing piece of cardboard to which a ruler or marked strip of paper has been fastened. Arrange so that "pointer" is almost touching the calibrations. As air pressure in room rises and falls, the rubber will expand and contract, and the pointer will change directions. Note the changes in writing. If possible, compare with changes being shown at the same time on a commercial aneroid barometer. Discuss what causes the changes.
4. Conserving Water Supply	Conservation of the water resources on earth are of extreme importance to man.	See Unit VI-Soil and Water Conservation in this course of study. Excellent free resource materials on the uses and conservation of water and soil may be had by writing: The U. S. Dept. of Agriculture Soil Conservation Service Milner Building Jackson, Mississippi Ask for the Mississippi Information Kit on Soil and Water Conservation.

Teaching Aid—Unit II.

CROSS-SECTION OF GLOBE (SPHERE) SHOWING THE FOUR MAJOR PARTS OF THE LITHOSPHERE.

(All depths are approximate.)



CRUST (3 to 25 miles thick)
Continents-made of granite, avg. 25 mi. thick.
Ocean floors,-made of basalt, avg. 3-4.5 mi.".
(Mohorovcic discontinuity - base of crust)

MANTLE (1800 miles thick)
Made of rock, probably olivine.

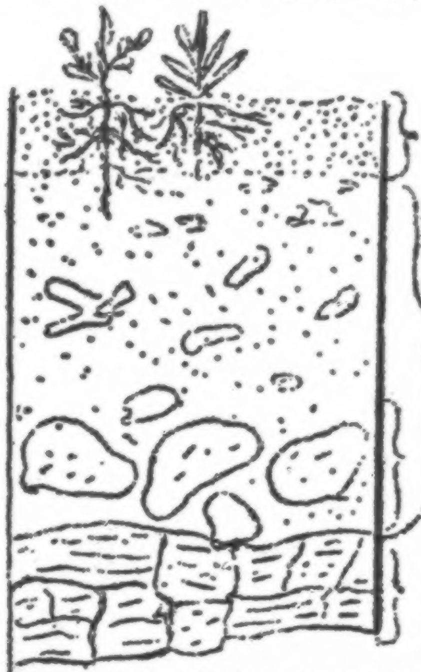
OUTER CORE (1300-1360 miles thick) Made of molten (semi-liquid) iron & nickel. Origin of earth's magnetic field.

INNER CORE (860-900 miles thick to center, i.e., the radius; diameter-1720-1800 miles.) Probably iron & nickel in solid state.
(Some geologists favor the theory of an iron-silicate composition of earth's core.)
Earth's diameter — approximately 8,000 miles.
Earth's circumference - approximately 25,000 miles.

CHART: PARTS OF EARTH ACCORDING TO THE FORMS OR STATES OF MATTER.

Forms of Matter:	Parts of Earth:	Includes:
1. gas	atmosphere	gases, clouds, etc.
2. liquid	hydrosphere	water of earth (rivers, oceans, etc.)
3. solid	lithosphere	rocks, minerals, soil, etc.

LAYERS OF EARTH'S CRUST (SOIL PROFILE).



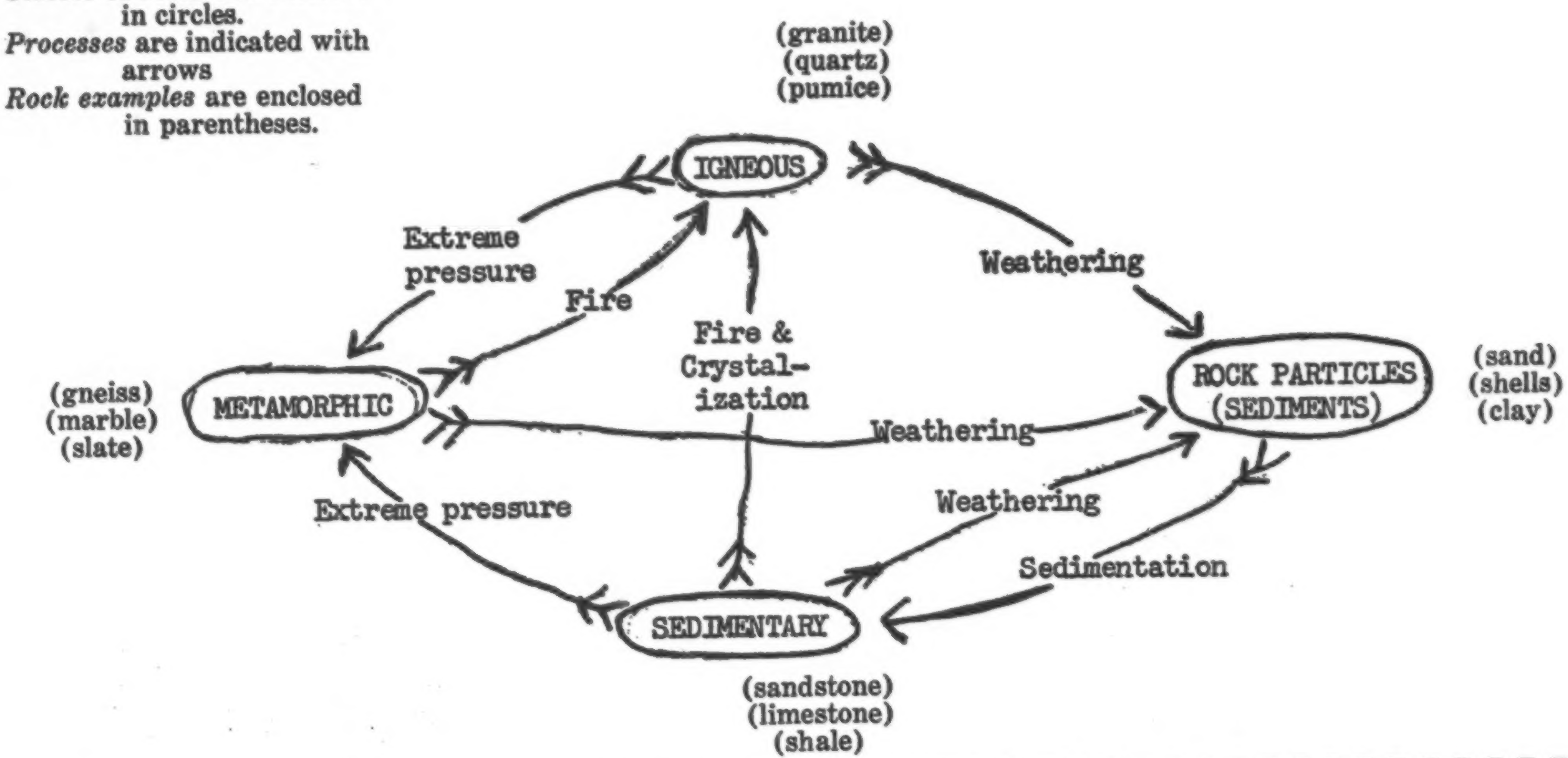
Layers:	Ability to support growth:	
TOPSOIL	Fertile	Fine rock particles. Minerals — inorganic material Humus—organic material Microorganisms—living Water and air; space
SUBSOIL	Semi-fertile	Larger rock particles. Much smaller amounts of humus, microorganisms, minerals, etc.
(Parent Material)	Source of subsoil	
BEDROCK	Comes from mantle rock. Non-fertile	

References: LIFE'S Picture Atlas, 1961; Science Service Program; National Geographic Magazine; Steck Co. Science Series; Van Nostrand World of Science Series; Macmillan Co., Book 8; Brinckerhoff, The Physical World; Zumberge, Elements of Geo.

Teaching Aid—Unit II

Classes of rocks are enclosed in circles.
Processes are indicated with arrows
Rock examples are enclosed in parentheses.

THE ROCK CYCLE


(granite)
(quartz)
(pumice)
IGNEOUS
Extreme pressure
Fire
Fire & Crystal-ization
Weathering
(gneiss)
(marble)
(slate)
METAMORPHIC
Weathering
ROCK PARTICLES (SEDIMENTS)
(sand)
(shells)
(clay)
Extreme pressure
Weathering
Sedimentation
SEDIMENTARY
(sandstone)
(limestone)
(shale)

CLASS OF ROCKS:	*Processes by which rocks are made:*	*Distinguishing characteristics:*
IGNEOUS	Fire: extreme heat	crystals (not always)
SEDIMENTARY	Sedimentation (settling)	layers
METAMORPHIC	Extreme pressure	hardness (may contain crystals and/or layers) (usually foliated) (often banded)

(All classes are broken down to rock particles, sediments, by weather and erosion.)

UNIT III—7th Grade

Topics	*Understandings*	*Suggested Activities*
Unit III—Introduction to Physics (The Study of Matter and Energy)		
A. Matter 1. What is matter?	Matter is anything which occupies space and has weight.	
2. States of matter	Matter is considered to be found in one or the other of three states, or forms: gas, liquid, solid. A possible fourth state of matter, cosmic plasma, has been discovered.	Demonstration: Show changes in form or state in ice, water, and steam by applying heat or removing it. Measure the amount of time necessary to make the above changes.
3. Properties of matter	All things have characteristics or properties, for example: a. A liquid takes the shape of its container, has weight, and occupies space. b. Mass, length, time, area, volume, and density are properties measurable by the scientist. c. Density is the quantity of matter per unit volume.	Experiment: Place an empty beaker in large bowl of water. First trap the air in beaker and then let students see that the air is being replaced with water. Experiments: a. Let students see how much water (or any liquid) will go into different sizes of containers. b. Weigh some object, such as a football, then inflate and weigh it again. The difference is the weight of the air in the ball. c. Measure the classroom; find its area.
4. Changes in states of matter	Conversion from one state of matter to another depends upon several factors. Among these are temperature change and pressure change.	
B. Energy and Force 1. Definitions 2. Relationships	Force is used to change the motion or direction of motion of a body. Energy is the capacity to make these changes or to do work. Work is the result of force moving a mass through a distance.	Develop demonstrations to help the students see a clear distinction between the vocabulary terms: force, energy, and work. Show that force may be exerted without work achievement.
	Energy may be dissipated with little or no useful work accomplished. (Low efficiency)	Many engineering efforts have been directed towards improvement of efficiency. Explain.

Reference for teaching density: ***Science for Progress*****, page 410.**

Topics	*Understandings*	*Suggested Activities*
Unit III—continued		
B. Energy and Force (continued)		
3. Kinds of energy	Energy is found in active or stored forms, kinetic and potential, respectively.	Film: "Our Mr. Sun," Bell Telephone Co. See film list, item no. 4. Film: "Energy," film list, item no. 2. Have students explain situations in which different kinds of energy are changed from potential energy to kinetic energy. Present an energy cycle. Demonstrate potential and kinetic energy by use of a pendulum. Use a string suspended so that it will swing freely. Attach a weight (rock, metal, etc.). Let student hold weight near his nose and let go of the weight. Will it swing back and hit the student?
4. Sources of energy	Energy is released through different means such as: burning of objects and substances, expanding gases, electricity, and magnetism. Some potential energy is released mechanically.	Have students build models or bring exhibits to demonstrate the various sources of energy and the means by which they are measured. Use apparatus to demonstrate the energy of freely falling weight. Carefully remove ends of fluorescent tube; wash tube and allow to dry. Stopper one end with cork or rubber stopper. Place a coin and a paper strip in the tube, fit other end with one-hole rubber stopper which has glass tube for attachment of suction pump, and evacuate air. The large diameter glass tube is also ob-

Topics	*Understandings*	*Suggested Activities*
Unit III—continued Sources of energy (continued)		tainable from a scientific supply house or from industry. (Note: Mercury and mercuric compounds are extremely poisonous. The above procedure for making the fluorescent tube model should be done only by responsible adults.) Develop a list of examples of each group of sources of energy such as: hammer as a falling weight, sling shot stretched object, jet fuel for expanding gases, etc.
5. Forms of energy	Energy is easily converted from one form to another, i.e., light to heat, electrical to mechanical, chemical to electrical, etc.	Have students create problems to illustrate series of changes in forms of energy: (a) at home, (b) at the service station, (c) on the farm, etc. For example: *Electrical* energy is changed to *heat* energy in the electric stove, while *chemical* energy is changed to *heat* energy in the gas stove; but *mechanical* energy is required to turn on either stove. Develop a list of examples of materials and objects which supply specific forms of energy such as: gasoline and food—chemical energy, gears and moving water—mechanical energy, light bulb — heat as well as light energy. Review the definitions of force, energy, work, and physics.
C. Simple Machines (Note: If this material has been		

Topics	*Understandings*	*Suggested Activities*
Unit III—continued taught in the sixth grade, this part of the unit may be omitted without adverse effect on the course of study.		Understand the definitions of the vocabulary terms which are especially important to this study: balance, imbalance, efficiency, friction, mechanical amplifier, mechanical advantage, power, horsepower.
1. Mechanical amplifier	Forces used in accomplishing work are aided by machines. Any machine is simply a device for transferring energy from one source to another. Any machine which increases force (effort) to a useable amount is called a mechanical amplifier.	
2. Mechanical advantage	The number of times a machine will increase force is the mechanical advantage of the machine. (A machine which reduces force provides a mechanical disadvantage.) However, some machines are designed for an increase of speed at the expense of the force.	
3. Balance	The mechanical advantage is based on the principle of shifting the balance (or imbalance) of forces.	To demonstrate the principle of balance: Drill a hole (¾") exactly at the 6" mark of a footrule for inserting a nail which will rotate freely. Cut small notches at each ½" and each 1" mark on the rule, or drill small holes in a straight line at these marks. Devise at least six small, equal, known weights to be hung at the ½" and 1" marks and which can be moved from one to

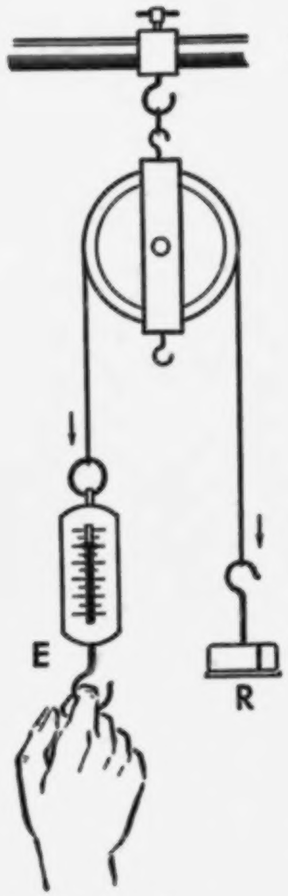
2

Topics	*Understandings*	*Suggested Activities*
Unit III—continued		another easily. Using this device, demonstrate the principle of balance.
		Allow students to develop their own rules and formulas from above demonstration.
		Use the formulas and rules for balance, creating and working problems on the balance. (See teaching aids.)
4. Kinds of machines	Complex machines which provide the greater forces or speeds are actually combinations of the simple machines: levers, pulleys (including the wheel and axle), simple inclined planes, wedges (double inclined planes), and the screw (spiralled inclined planes).	Filmstrip: "Simple Machines," see filmstrip list, item no. 56.
		Demonstrate the kinds of pulleys. Have class think of items at home or in the classroom which use pulleys. Explain how it is used. (See diagram next page)
	The purposes of simple machines are: to increase force, increase speed, or to change direction.	Using spring scales, have members of the class to measure differences in amount of force needed to lift a load a given height by using a pulley; then increase the number of supporting strands and measure the force again. (Another pulley may or may not be required.) What happens when the number of strands is increased? (See *The Physical World*, page 144.)

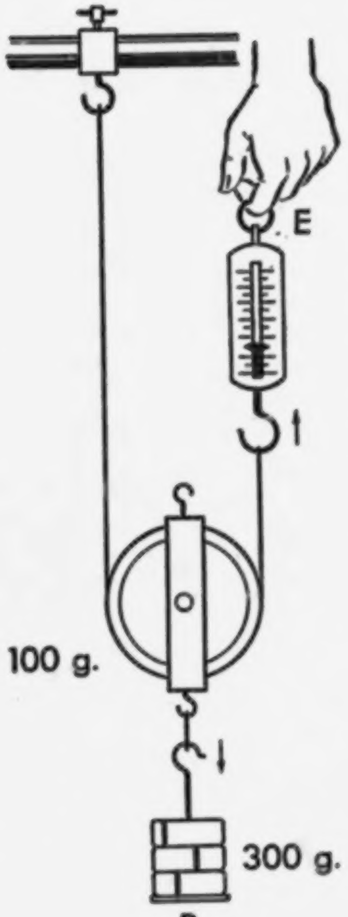
Unit III—continued

Kinds of machines (continued)

Understandings



Single fixed pulley



Single movable pulley

Suggested Activities

Filmstrip: "Inclined Plane, Wedge Screw," film list, item no. 57.

Determine how the three simple machines exhibited are related by having each member of the class do the following:

a. Cut a sheet of notebook paper in half lengthwise. Fold one half diagonally and cut again. The student now has two paper triangles (simple inclined planes.)

b. Letter the short side of the right angle "a"; letter the long side of the right angle "b"; letter the hypotenuse "c".

c. Color or blacken the edges of side "c" on each piece of paper.

d. Place sides "b" together. What do you now have? (wedge)

e. Now using one single inclined plane, starting with side "a", wrap paper around a pencil. What is the result? (The color on the edge of the paper should wind around the pencil so as to show the direction of the threads of a screw.) Thus we have a spiralled inclined plane.

Topics	*Understandings*	*Suggested Activities*
Unit III—continued		
5. Levers	Levers operate on the principle of distribution of weight; based on the principle of balance. Their mechanical advantage is indicated by the ratio of the distance the force (effort) moves to the distance the load (resistance) moves also by a ratio of the two lever arms.	Demonstrate classes of levers: a. Have students draw simple diagrams of: scissors, wheelbarrow, baseball bat; and indicate the position of the fulcrum, the direction of force and load on each drawing. b. Exhibit familiar tools employing principles of levers. c. Explain the application of principles involved. Create and solve problems on levers, using the formulas. (See teaching aids.)
6. Inclined planes	Inclined planes operate on the principles of angles and triangles. Their mechanical advantage is indicated by the ratio of the distance the load is moved to the height the load is lifted.	Exhibit models of an inclined plane, a screw, and a wedge.
7. Efficiency	The *efficiency* of a machine is reduced by *friction* (resistance to movement). Efficiency means comparing the useful work output (work done by the machine) with its work input (work put into a machine.) Mathematicaly, efficiency is equal to *the work output divided by the work input.* Since efficiency can never be 100% in any machine, but is always less, the term should not be confused with mechanical advantage.	Derive a formula from the definition of "efficiency." Using the formula: Work equals force × distance, create problems to be solved finding the work done when a given force moves a load a given distance. Problem: An auto jack may take 4000 foot-pounds of your work (pumping its handle up and down) to raise 2000 pounds the distance of one foot; that is to produce 2000 foot-pounds of useful

Topics	*Understandings*	*Suggested Activities*
Unit III—continued 7. Efficiency (Continued)		work output. What is the *efficiency* of the jack? (See Reference below.) Film: "Energy and What It Does," film list, item no. 59.
8. Power	The consideration of time in relation to amount of work done is important in a study of machines. The meaning of the term "power" is limited to the amount of work done in a given time, i.e., the rate of doing work, or mathematically, power is equal to the work done divided by the time needed to do it.	Demonstrate the relation of force to speed. Obtain a set of at least three gears (consider the toy store), or make a simple set from wood or cardboard. Define the parts (cog, mesh). Rotate the large gear and observe the number of times and the speed at which each of the other gears turns. Test the other gears in turn. Determine the ratio of force and speed between the gears. Which size has the most force? Which size has the most speed? Is there a direct relationship between the number of cogs and the diameter of each gear; between the number of cogs on one gear to that on each of the other gears? If so, what is the relationship? Problems on power: a. Let one member of the class *run* a set distance on level ground. Record these facts about the event; distance run, weight of runner, force required, time required. (Assume the force of frictional resistance to be .1 of the weight of the runner.)

Reference—*The Physical World*, pages 138, 142.

Topics

Unit III—continued

Power—(continued

Machines, especially motors, are usually rated in units of horsepower, a term which was invented by James Watts.

Understandings

b. Let one member of the class *walk* a given distance (on level ground). Record the same type of data. Assume that the resistance is the same.

c. Make a table using the information from the two events.

d. Using the formula for power:

(1) determine the amount of work done in each case; (2) determine the amount of power produced in each case; and (3) compare the results.

$$\text{Work} = \text{Force} \times \text{Distance}$$

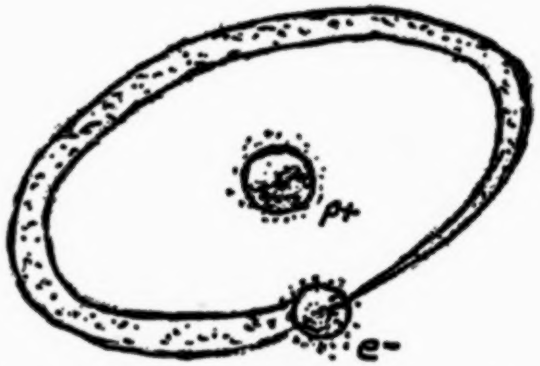
$$\text{Power} = \frac{\text{Work}}{\text{Time}}$$

Problem: Suppose a strong man requires 3 seconds to lift a 300 lb. barbell to a height of six feet. How much work does this man do? How much power is produced?

Have a member of the class give a report on how the term "horsepower" originated. (See Reference page 62).
A horse can pull with a force of 180 lbs. around a circle about 23 feet in diameter and can make about 2½ round

Topics	*Understandings*	*Suggested Activities*
Unit III—continued Power - (continued)		trips per minute. a. What is the distance the horse walked in one trip? b. What is the distance the horse walked in one minute? (Definition of horsepower today is: One horsepower equals 33,000 foot-lbs. of work per minute.) c. What is the work done by the horse in one minute? d. What is the work done by the horse in one second? e. How does the power of the horse compare with the standard horsepower? f. Referring to the problem about the strong man, how much horsepower was used to lift the bar-bell? g. Average manpower is 46 foot-pounds per second. What is the average man's horsepower? (0.084 horsepower)
D. Atoms and Molecules	An atom is the smallest subdivision of a chemical element that can take part in a chemical change.	Library research: Look for accounts of the discovery of protons, electrons, and neutrons.
1. Atoms (See teaching aid at the end of the unit.)	An atom has most of its mass concentrated in the nucleus, which contains	Make a model of a carbon atom (and others) using different colored beads

Topics	*Understandings*	*Suggested Activities*
	mainly protons (positively charged particles) and neutrons (particles with no charge). The nucleus is surrounded by a cloud of electrons (negatively charged particles), whose mass is negligible compared to that of the nuclear particles. These electrons may occupy varying levels of energy, depending on their distance from the nucleus. It is difficult to say where an electron may be found at any given moment. The best one can do is to make a statement concerning the probability of finding an electron at a certain place. This results in a sort of fuzzy picture of an atom, like one taken with a camera out of focus; hence, the use of the term electron cloud.	for protons, neutrons, and electrons. Use stiff wire to represent orbitals, and to support the electrons.
	An atom is electrically neutral. The number of protons in the nucleus equals the number of electrons outside the nucleus.	
2. Diagram of the simplest atom	Except for the nucleus, an atom is largely space.	

Topics	*Understandings*	*Suggested Activities*
Unit III—continued		 The hydrogen atom pictured here is the simplest atom known; it has a single proton in the nucleus, and one extranuclear electron.
3. Molecules	A molecule is the smallest division of a substance which retains the properties exhibited by the substance. Molecules may consist of only one atom, or they may contain several atoms. For example, a molecule of helium is monatomic. A molecule of hydrogen (H_2) contains two atoms (diatomic), while a molecule of ammonia gas (NH_3) has four atoms .	
E. Basic Magnetism and Electricity	Some materials become magnetized when groups of molecules (domains) arrange themselves in such a manner	Place bar magnets under a sheet of glass, or paper, sprinkle with iron filings. Lines of force will develop. Rear-

Topics	*Understandings*	*Suggested Activities*
Unit III - continued		
1. Magnetism	as to have opposite electrical properties. The ends of the magnetized material will align the material with the magnetic field near the north pole. These opposite ends are referred to as north-seeking and south-seeking, or, as positive and negative poles. Magnets can be made by conduction, induction, and temporarily by electricity. Heat or a sudden jar will destroy a magnet by disturbing the alignment of the domains.	range magnets to show changes in lines of force when like and/or unlike poles are placed near each other. Also demonstrate with horseshoe magnet. Film: "Magnetism," film list, item no. 62. Using a metal object, such as a paper clip, needle, etc., demonstrate making of magnets by conduction and induction. Plans for making electromagnets may be found in many books. An insulated wire wound around a large nail is a simple form. After making the simple magnets, have students destroy the magnetism by heating and dropping them. With a compass, 'explore' the room for local distortions (deviations) of the earth's field. Note: Metal table, radiator, etc. may affect the field. Discussion of earth as a magnet. Refer to publications reporting findings of the International Geophysical Year,

Topics	*Understandings*	*Suggested Activities*
Unit III—continued Magnetism (continued)		concerning earth's magnetic field. (Student Report) Film: "Ferromagnetic Domains," Bell Telephone Company. Film list item 10.
2. Electricity	Electricity is concerned with restricted movement of electrons (static) or the movement of electrons along a conductor (current). Current electricity moves in a circuit always with some resistance. Materials and people are protected from the flow of electrons by nonconductors of electricity, called insulators.	Topics for discussion: Lightning, radio static, seat cover shock, etc. Simple demonstrations of electrostatics: a. Running comb through hair, picking up paper. b. Rub a glass rod with silk; then place close to bits of paper; repeat process rubbing with wool. c. Other demonstrations may be found in many books. Using strings of Christmas tree lights, demonstrate the principles of series and parallel circuits. A simple device for demonstrating open and closed circuits may be made by the following methods. Using a two or a three foot length of extension cord: install a wall plug on one end, insert a standard light receptacle by cutting one of the wires; install a throw-switch between the open ends of the cord. By opening and closing the switch, open and closed circuits may be shown.

Topics	Understandings	Suggested Activities
Unit III—continued Electricity (continued)		Adaptations of this device may be made so that demonstrations of the conductivity or resistance of various materials may be done. Metal plates separated by porcelain insulators may be installed in place of the switch. Place materials to be tested for conductivity across the plates. Care should be exercised in using house current. The same circuit may employ a dry cell or battery where no danger is involved.
F. Study of Light	Visible light which man uses is a small segment of the wave energy produced by the sun and by artificial means. Light travels in a straight line at an almost constant speed and can be changed in direction by refraction, reflection, and diffraction.	Use prism to show how light is separated into its various wave lengths, which are seen as colors. A pencil or finger placed in a glass of water will demonstrate the *refraction* of light. The "Law of Reflection" (see teaching aid) may be demonstrated in the following way. Place a large mirror in front of the middle desk. With masking tape, fasten the middle of a very long string to the midline of the mirror. Let a student on one side of the room hold one end of the string at his desk. Then give the other end to a student on the opposite side of the room. Hold the string so that it appears straight in the mirror from one viewer to the other. As each student looks down the string,

Topics	*Understandings*	*Suggested Activities*
		the image of the other student will be in line with the string. Measure the angles made by each part of the string to the midline of the mirror. Repeat using other students. Sunlight through a magnifying glass on paper shows the focusing of heat energy as well as light energy.
G. Study of Sound	Sound is energy in the form of wave motion which is mechanically produced through vibrations of material. Its main characteristics are pitch (frequency), loudness (amplitude), and tone (quality).	Use of tuning forks. Experiment with the transmission of sound through wood, water, metal, plastic, etc.
		Film strip, "Looking at Sound," film strip list item No. 58.
		Use library and encyclopedias for drawings, posters, and reports on the characteristics of sound, for information concerning types of materials which conduct sound.
		Compare as to speed and distance of conduction.
		Reports on sound barrier, sonic energy, and sonar.
		If available, an oscilloscope can be used to demonstrate visually the characteristics of sound. Use a standing wave of 60 cycles.
		If available, use an audio-oscillator to demonstrate the characteristics of sound.

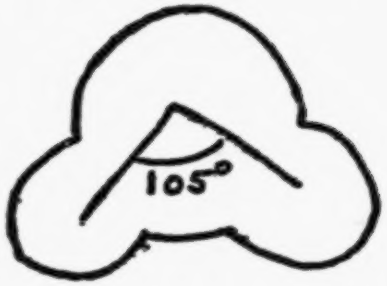
Topics	*Understandings*	*Suggested Activities*
		Disc recordings on sound are available from school supply companies of Mississippi. "The Science of Sound," "Sounds of Frequency," etc. Also films-Bell Tel. Co.: "Music in Motion-How Bell Scientists Analyze Sound," "Mr. Bell-As Inventor and Teacher of the Deaf." Many books describe the making of tin can telephones.

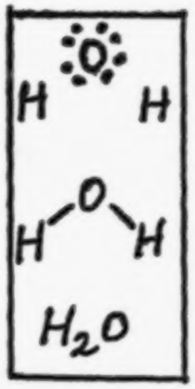
TEACHING AID, UNIT III, ATOMS AND MOLECULES

The Nature of Matter

- I. Molecules
  - A. Building blocks of all matter
  - B. The smallest particles into which matter can be divided without losing the characteristics of identity which the matter has
- II. Atoms
  - A. The smallest particle of an element which can take part in a chemical change
  - B. An atom may be divided into two general regions.
    - 1. The nucleus
      - (a) proton - a particle with a positive charge
      - (b) neutron - a particle with no charge
    - 2. Extranuclear space
      - (a) electron - a particle with a negative charge
      - (b) varying energy levels
    - 3. Other subatomic particles
  - C. Atoms are electrically neutral.
  - D. Most of the mass of an atom is concentrated in its nucleus.
- III. Relationship between atoms, molecules, and ions
  - A. Molecules *usually* contain two or more atoms.
    - 1. Like atoms - the hydrogen molecule (H_2)
    - 2. Unlike atoms - carbon monoxide (CO)
  - B. Some molecules are *monatomic.*
  - C. Ions are formed
    - 1. When an atom loses electrons ($Na^0 - le \rightarrow Na^+$)
    - 2. When an atom gains electrons ($Cl^0 + le \rightarrow Cl^-$)
  - D. Atoms combine to form molecules through *the sharing of electrons* (covalence)
  - E. When electrons are gained and lost, *ionic* compounds are formed. They *are not* molecular. Example:
    $Na^+ Cl^-$ (This is *not* a molecule.)
    Water is a *molecular* substance. The atoms *share* electrons.

The Water Molecule:

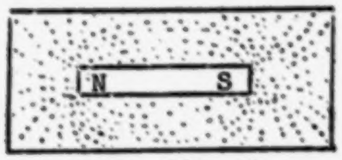




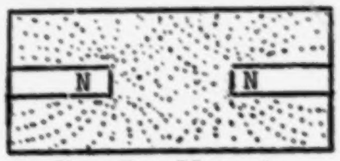
Teaching Aid — Unit III, Basic Magnetism and Electricity

THE BEHAVIOR OF MAGNETIC SUBSTANCES IS KNOWN AS GILBERT'S LAW.

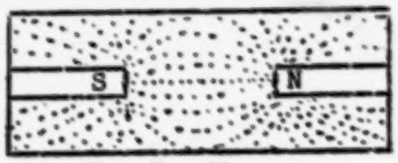
The lines of force (magnetic field) around the poles of magnets:



Single Bar Magnet



Two Bar Magnets
Like poles
(repel)



Two Bar Magnets
Unlike poles
(attract)

KINDS OF MAGNETS:

a. natural—example, lodestone
b. artificial
  (1) temporary
  (2) permanent

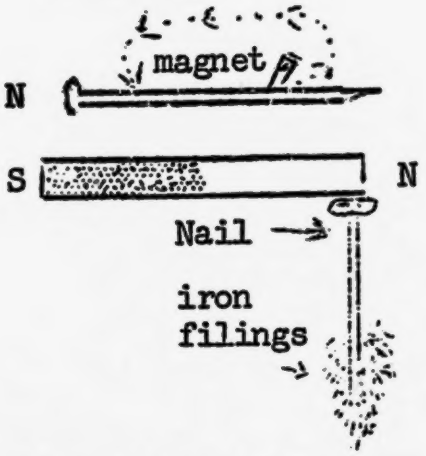
THE THEORY OF MAGNETISM:

A magnetic substance is made up of domains, each of which is a magnet itself. When the substance is magnetized, the domains are arranged with all the north poles pointing in one direction and all the south poles pointing in the other direction. When the substance is not magnetized, the domains are arranged in a disorganized fashion.

Cutting a bar magnet in pieces can prove the magnetic theory.

MAGNETS ARE MADE BY ONE OF THREE WAYS:

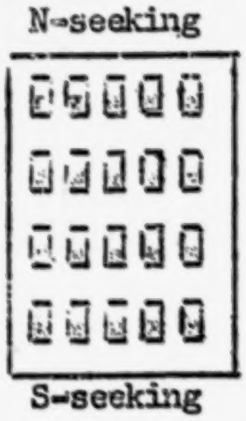
1. **Conduction**
2. **Induction**
3. **Electricity**
   (electromagnets)


magnet
N
S
N
Nail
iron filings

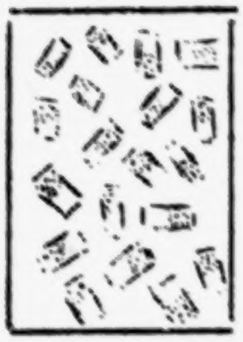
TEMPORARY MAGNETS ARE DESTROYED BY TWO WAYS:

1. **Heat**
2. **Sudden jarring**

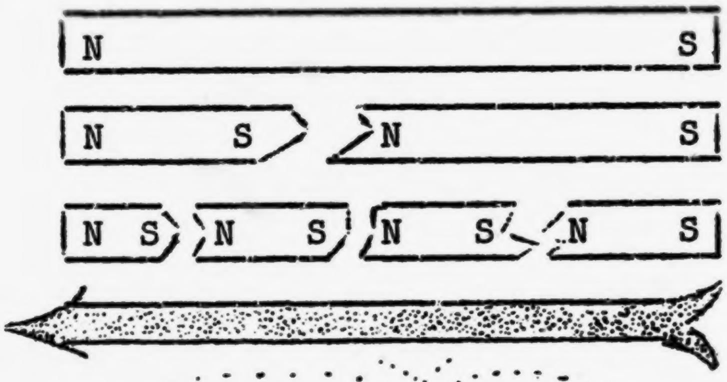
THOUGHT QUESTION: Can you relate the Electron Theory to the Theory of Magnetism?


N-seeking
S-seeking

Magnetized Bar



Unmagnetized Bar


N
S
N
S
N
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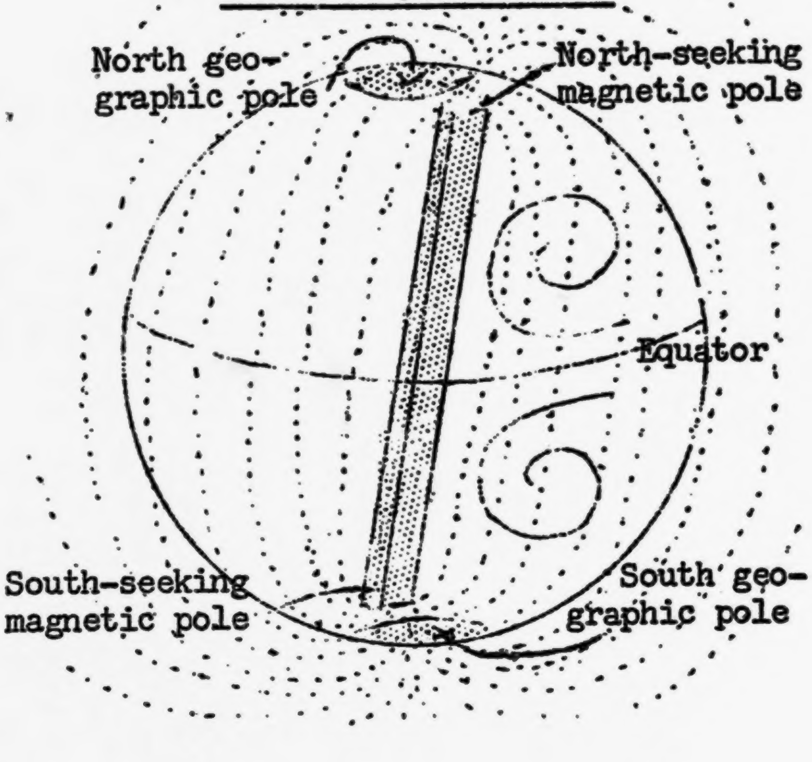
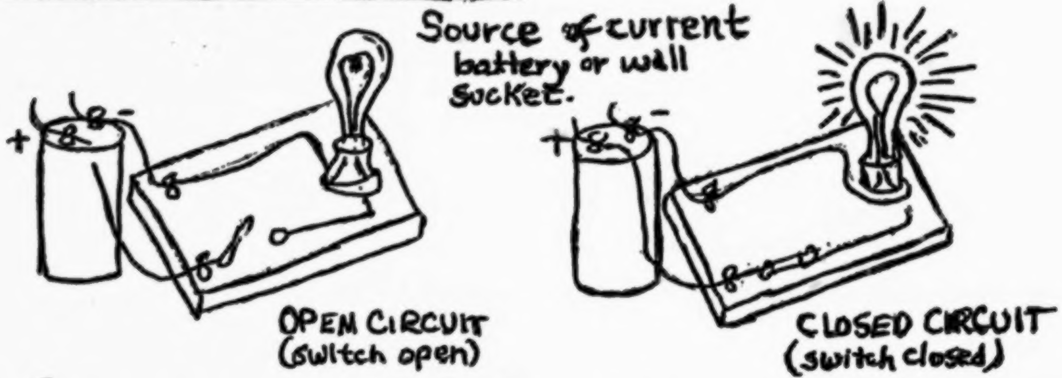
N
S
N
S
N
S
N
S

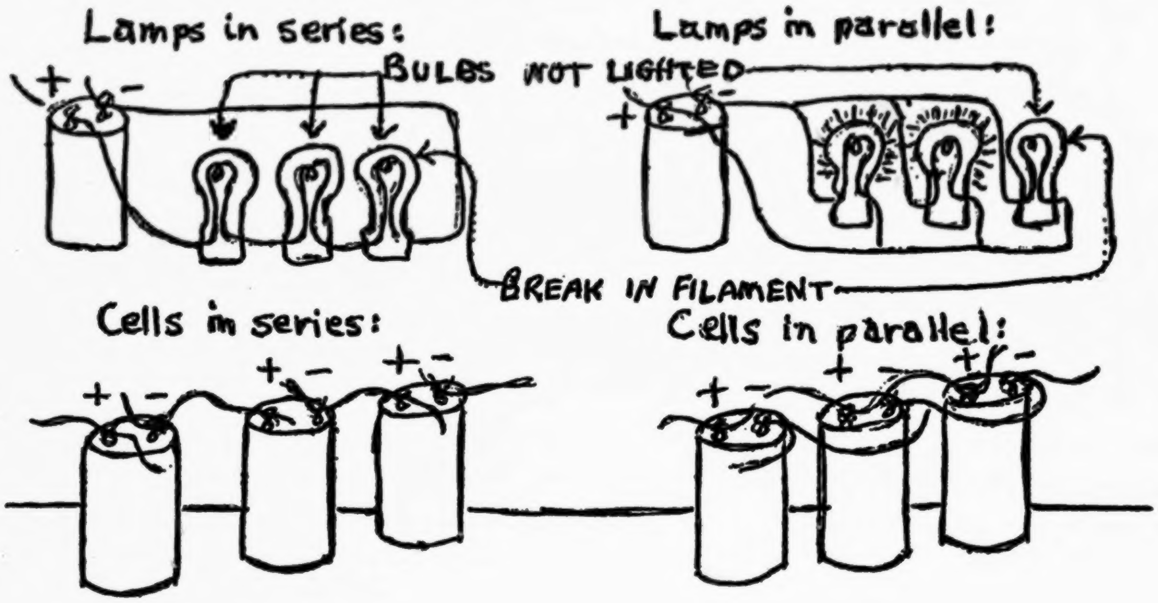
THE EARTH IS A MAGNET


North geographic pole
North-seeking magnetic pole
Equator
South-seeking magnetic pole
South geographic pole

Electrical Circuits

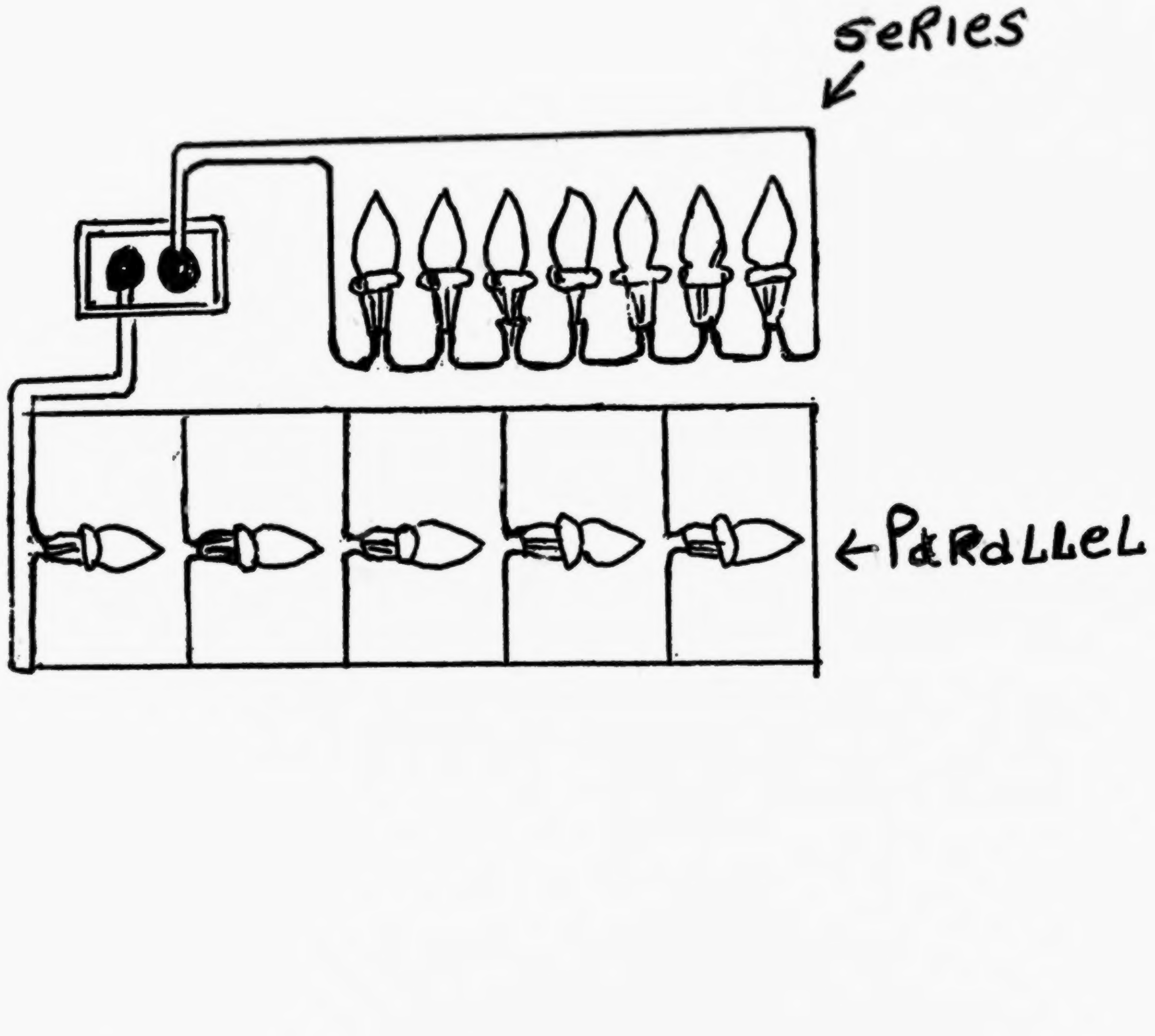

Source of current battery or wall socket.
+
-
OPEN CIRCUIT (switch open)
CLOSED CIRCUIT (switch closed)

Series and Parallel Circuits


Lamps in series:
Lamps in parallel:
BULBS NOT LIGHTED
BREAK IN FILAMENT
Cells in series:
Cells in parallel:
+
-

In a *series circuit,* the current flows through each and all the electrical devices (such as cells, light bulbs, switches, etc.) before returning to the source. If there is a break in any part of a series circuit, or if an appliance is turned off, the entire circuit becomes opened and the current no longer flows.

A *parallel circuit* consists of a number of branches, each of which is independently connected with the source. If there is a break in a parallel circuit, only that branch is affected. All other branches remain closed circuits and thus the current continues to flow through them. For this reason, all electrical appliances in the home are wired in parallel.


SERIES
PARALLEL

Teaching Aid — Unit III, A Study of Light

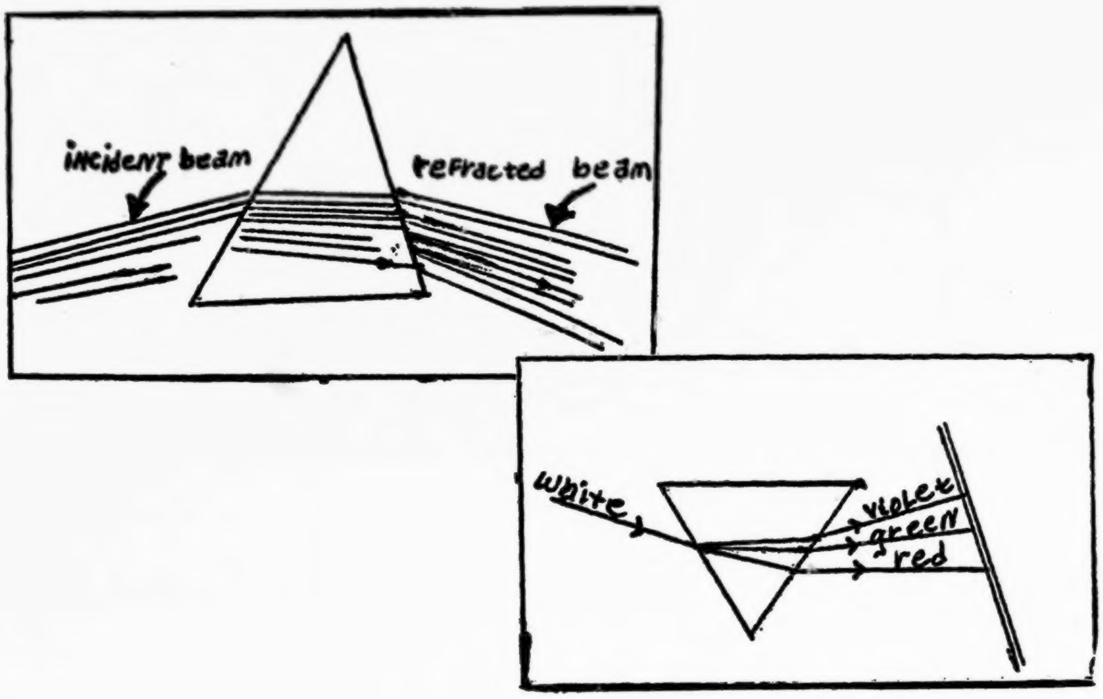
LIGHT MAY BE EITHER REFRACTED OR REFLECTED.

There is a principle which explains each process.

REFRACTION means the bending of light rays. When light is refracted the rays may be not only bent but also separated into the segments which make up the ray of light. Substances or objects, such as water or a prism, may serve as refractors of light.

When a prism is used to refract light, the ray of light may be broken into its separate segments of different lightwave lengths. Each of these different wavelengths will result in a different ray of colored light. The density of the substance will determine the degree to which light may be bent. The ray of light bends toward the perpendicular on entering the denser medium, away from the ⊥ on leaving the denser medium.

The drawing illustrates a ray of white light being refracted by a prism. The right hand column of terms indicates the wavelengths of energy from the sun in their respective order.

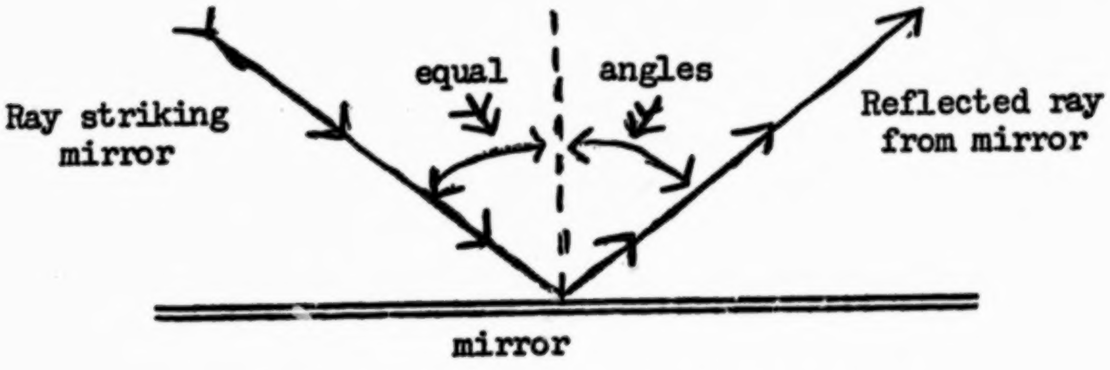


Sound waves
Long waves
(Standard broadcast) } RADIO
Short wave
VHF
Radar UHF
TV
Infra-red waves
RED
ORANGE
YELLOW
GREEN
BLUE
VIOLET
} THE SPECTRUM (band of color)
Ultraviolet waves
X-rays
Cosmic rays (mostly in space)

{ White light and the spectrum are the only visible portions of light.*

THE PRINCIPLE OF REFRACTION: As light energy passes through a substance it is bent and/or separated into different lightwave lengths.

THE LAW OF REFLECTION: The angle at which a ray of light reflected from an object strikes the mirror EQUALS the angle at which the reflected ray leaves the mirror. In other words, THE ANGLE OF INCIDENCE EQUALS THE ANGLE OF REFLECTION.


equal
angles
Ray striking mirror
Reflected ray from mirror
mirror

Angle of incidence equals *Angle of Reflection*

*(Note: This means without the aid of special devices. Under special conditions ultraviolet and infra-red rays may be seen.)

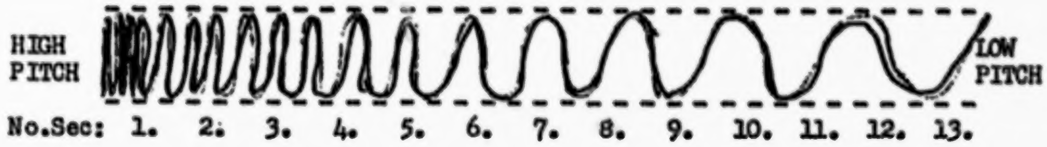
Teaching Aid — Unit III, A Study of Sound

TABLE ON CHARACTERISTICS OF SOUND:

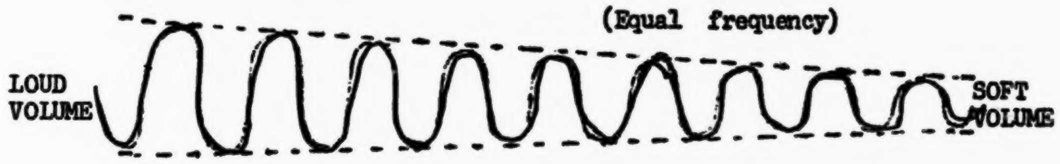
Characteristics	*Described as:*	*Depends upon:*
1. pitch	high, medium, low	number of vibrations per second (frequency)
2. volume	loud, medium, soft	energy of the sound wave (amount and intensity)
3. tone or quality	"sounding like . . . ." pleasing or displeasing; good or bad, etc.	manner in which object is vibrating (wave form)

ALL THESE DIAGRAMS ARE PICTURES OF SOUND WAVES. Each shows one of the characteristics of sound.

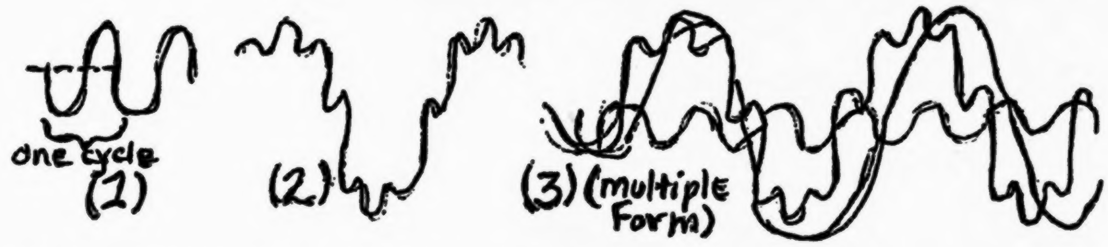
PITCH: Number of vibrations (rate) per second. The human ear cannot hear below 16 nor above 20,000 vibrations per second, on the average. The scientific way of expressing this fact is to say that the range of human hearing is from 16 cycles to 20,000 per second.



VOLUME: Amount and intensity (strength of sound wave). Pictured as height of wave:



QUALITY: Pictured as shape of wave (wave form). Determined by manner in which sound is made. Described as "sounding like . . . . ."



THE HUMAN EYE IS LIMITED TO THE SIZE OF THE WAVELENGTH OF LIGHT IT CAN SEE.

THE HUMAN EAR IS LIMITED TO THE RATE OF SOUND WAVES IT CAN HEAR.

VOCABULARY STUDY. Include these terms:

1. compression
2. transmitter
3. auditorium
4. auditory nerve
5. audio-oscillator
6. oscilloscope

Teaching Aid—Unit III, Simple Machines

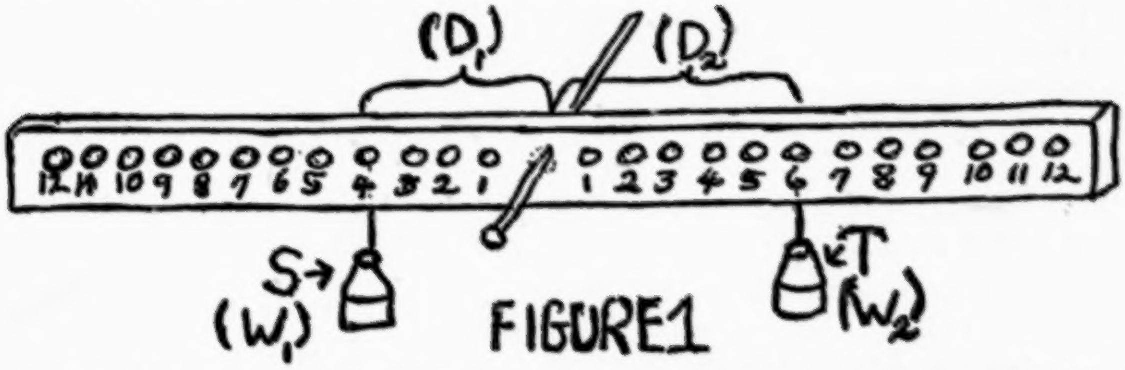

(D1)
(D2)
12 11 10 9 8 7 6 5 4 3 2 1
1 2 3 4 5 6 7 8 9 10 11 12
S→
(W1)
←T
(W2)

FIGURE1

BALANCE—a state in which the combination of factors on one side of a point equals the combination of factors on the other side of that point.

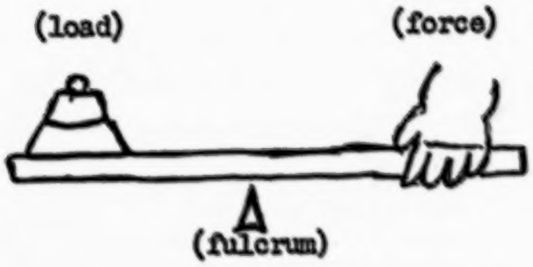

(load)
(force)
(fulcrum)

FIGURE2
(1st class lever)

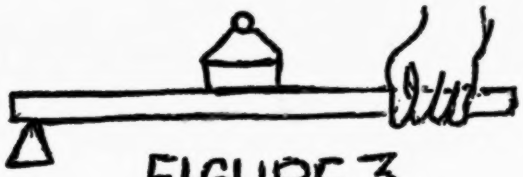


FIGURE 3
(2nd class lever)

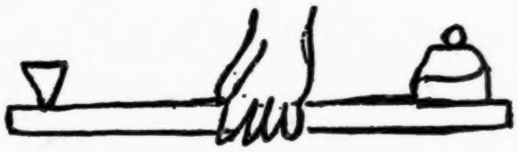


FIGURE 4
(3rd class lever)

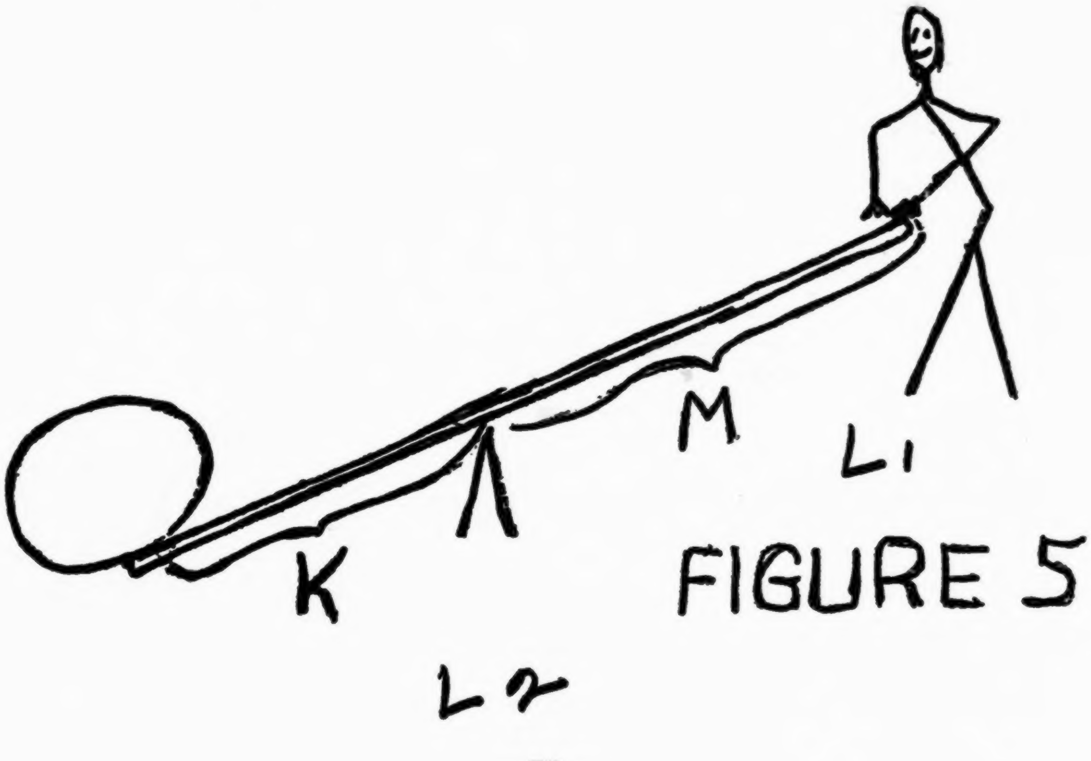


FIGURE 5

Teaching Aid—Unit III, Simple Machines

FIVE STEPS FOR SOLVING PROBLEMS OF SIMPLE MACHINES:

(These must always be done in the order given.)

1. Write the equation or formula.
2. Rewrite the equation substituting the known values in their proper places.
3. Assign the letter "X" to the unknown value.
4. Solve the equation or formulas for X.
5. CHECK YOUR SOLUTION BY:
   - (1) Writing the equation or formula.
   - (2) Rewriting the equation substituting the known values in their proper places.
   - (3) Substituting the value you received for X when solving the problem.
   - (4) Working the problem. If you get the same figure on both sides of the equation or formula, then your solution for X is correct because the two sides are in balance.

FORMULAS FOR SOLVING PROBLEMS OF SIMPLE MACHINES:

1. Balance: $W_1D_1 = W_2D_2$ Weight times distance on one side equals weight times distance on the other side.

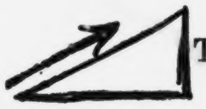
2. Lever: Theor. MA $= \frac{L_1}{L_2}$ $\frac{\text{length of force arm of lever}}{\text{length of resistance arm of lever}}$

3. Fixed pulley: Unity one; no increase in force (Only the direction is changed.)

4. Single moveable pulley: Theor. MA $= 2:1$ which is derived from: $\frac{d}{r}$ $\frac{\text{diameter of pulley}}{\text{radius of pulley}}$

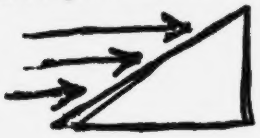
5. Wheel and axle: Theor. MA $= \frac{r_1}{r_2}$ $\frac{\text{radius of wheel}}{\text{radius of axle}}$

6. Inclined planes:
   a. (Force applied parallel to the plane.)



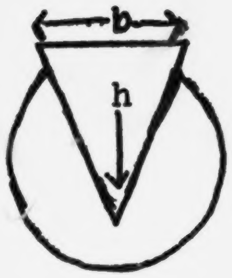
Theor. MA $= \frac{l}{h}$ $\frac{\text{length of incline}}{\text{height raised}}$

   b. (Force applied parallel to base.)



Theor. MA $= \frac{b}{h}$ $\frac{\text{length of base}}{\text{height raised}}$

7. Wedge: (A double inclined plane.) Theor. MA $= \frac{h}{b}$ $\frac{\text{height}}{\text{base}}$



(Note: There are other formulas than these for solving the mechanical advantage problems of simple machines. Some teachers may prefer to use their own.)

Teaching Aid—Unit III, Simple Machines

SAMPLE PROBLEMS ON BALANCE AND LEVERS:

(Apply the 5 problem - solving steps.)
What is the formula for solving problems on balance?
IN FIGURE 1, S is hung at 4 in. and T is hung at 6 in.:

1. If S weighs 9 pounds, how much does T weigh?
   What part of the formula did you solve for?
2. If S weighed 10 pounds, and T weighed 4 lbs.; and, if T were hung at 5 in.; where would S be hung? What part of the formula did you solve for?
3. If your known values are:
   $S = 3$; $T = 6$; $D_2 = 9$, what is the value of the unknown? What part of the problem did you solve for?
4. If your known values are:
   W_1 is 3; W_2 is 4; D_1 is 8; what is the value of the unknown? What part of the formula did you solve for?

PROBLEMS ON LEVERS: (Figure 5)

What is the formula for finding the theoretical mechanical advantage of simple levers?

If the rock weighs 75 lbs., and, if K is 3 ft. long, and M is 9 ft. long:

5. How much force (F) would the man need to move the rock?
6. What is the theoretical mechanical advantage of the lever?

If the rock weighed 120 lbs., and if l_1 is 8 ft., and the man used 20 lbs. force:

7. How long would l_2 have to be to move the rock?
8. What is the theoretical mechanical advantage of the lever?

Write your problems in these spaces using the formulas:	Prove your answers in these spaces:
(1) $W_1D_1 = W_2D_2$ $9 \times 4 = X \times 6$ $36 = 6X$ $36 = 36$	$9 \times 4 = 6 \times 6$ $36 = (6)6$ $36 = 36$
(2) $W_1D_1 = W_2D_2$ $10 \times X = 4 \times 5$ $10X = 20$ $X = 2$	$W_1D_1 = W_2D_2$ $10 \times 2 = 4 \times 5$ $10(2) = 20$ $20 = 20$
(3) $W_1D_1 = W_2D_2$ $3 \times X = 6 \times 9$ $3X = 54$ $X = 18$	$3 \times 18 = 6 \times 9$ $3(18) = 54$ $54 = 54$
(4) $W_1D_1 = W_2D_2$ $3 \times 8 = 4 \times X$ $24 = 4X$ $6 = X$	$W_1D_1 = W_2D_2$ $3 \times 8 = 4 \times 6$ $24 = 4(6)$ $24 = 24$
(5) $W_1D_1 = W_2D_2$ $75 \times 3 = X \times 9$ $225 = 9X$ $25 = X$	$W_1D_1 = W_2D_2$ $75 \times 3 = 25 \times 9$ $225 = (25)9$ $225 = 225$
(6) $\text{Theor. MA} = \frac{L_1}{L_2}$ $\text{Theor. MA} = \frac{9}{3}$ $\text{Theor. MA} = 3$	$F \times MA = \text{Resistance}$ $25 \times 3 = 75$, rock $75 = 75$ — — — or — — — $\frac{R}{MA} = F: \frac{75}{3} = 25$ $25 = 25$
(7) $W_1D_1 = W_2D_2$ $120 \times X = 20 \times 8$ $120X = 160$ $X = 1\,1/3$	$W_1D_1 = W_2D_2$ $120 \times 1\,1/3 = 20 \times 8$ $160 = 160$
(8) $\text{Theor. MA} = \frac{L_1}{L_2}$ $\text{Theor. MA} = \frac{8}{1\,1/3}$ $\text{Theor. MA} = 6$	$F \times MA = R$ $20 \times 6 = 120$ $120 = 120$

UNIT IV—7TH GRADE

Topics	*Understandings*	*Suggested Activities*
Unit IV. Introduction to Chemistry		Field trip to chemistry laboratory of school or industry as introduction.
A. Review of Atomic and Molecular Structure (Refer to Unit on Physics)		Use models constructed in previous unit. Have students make models of other elements.
B. Table of Elements	In the periodic table the elements are arranged in order of increasing atomic number. Location of a given element on the chart will indicate the physical and chemical properties of that element.	Chart Study: Atomic Table of Elements (A detailed description of a hypothetical classroom situation on this topic of study is attached. It illustrates how the method of fluid inquiry, using the step by step process in the Unit II Supplemental Activity, "How to State and Solve a Problem," is developed in the classroom. The attached situation includes Part A of this unit, the review of atomic and molecular structure.) Materials needed: Periodic Table of the Elements (classroom size) Individual copies of a list of the elements, alphabetically arranged, with symbols, atomic numbers, and atomic weights (Welch may provide 1 class set free.) Plan experiments which can be repeated that relate to the position of the elements on the periodic chart.

Topics	*Understandings*	*Suggested Activities*
Unit IV Continued B. Table of elements (continued)		a. Have students select the name of 10 or more elements with which they are familiar. List these elements with their symbols and atomic numbers. Rearrange the list in order of the atomic number. b. Locate these elements on the chart.
	The materials which make up a mixture retain their original properties.	Light a wood splint. Then blow it out. While the splint is still glowing, hold it near the top of the test tube as you continue to heat the red powder in the bottom of the tube. The splint will burst into flame. The gas coming from the red powder is oxygen.
	Symbols are *more* than abbreviations for the names of elements, although they are very definitely that. Each element has a symbol. It may also have a *formula.* For example, the symbol for oxygen is O, its formula is O_2. Formulas are not necessarily confined to compounds. There are several kinds of chemical formulas. The one most commonly used denotes the composition of the substance, giving the number and kind of atoms present. For example, we write the formula for water as H_2O. This tells us that water contains two atoms of hydrogen and one of oxygen. It is obvious that the symbol of the element stands for one atom of that element or one atomic weight of that element.	Observe that the red powder seems to darken as you heat it. Watch the powder as it cools. It becomes bright orange-red. What chemical action is taking place in the test tube? Experiment showing presence of carbon dioxide in exhaled air: Fill a glass or beaker with clear, filtered limewater. Gently blow through a drinking straw into the glass. Watch the limewater gradually turn milky. Explain why this happens.
	A *compound* is a pure substance, made by the chemical union or two or more elements. For example, the sugar in	Write the chemical equations for each of the above experiments showing the reaction of the elements in the compounds.

Topics	*Understandings*	*Suggested Activities*
Unit IV. (Continued) B. Table of Elements (Continued)	your tea has the formula $C_{12}H_{22}O_{11}$, which indicates that twelve atoms of carbon, twenty-two of hydrogen, and eleven of oxygen have in some way combined, giving up their own properties and producing a different substance, sugar. (Sugar is not like carbon (black), hydrogen (gas), or oxygen (gas). The chemist writes the story of a chemical reaction in the briefest possible way. To do this, he uses chemical, mathematical, and physical symbols, very few if any words. The result is the chemical equation. Example: $HgO \xrightarrow{\Delta} Hg + O_2 \uparrow$ (Priestley's experiment)	Locate and explain equations which illustrate the chemical process of oxidation by fire and rusting. Study different kinds of fire extinguishers for their contents and determine why each type will put out fires. c. Write the physical and chemical properties for each element listed. Notice similarities between elements near each other on the chart, and the differences between those far apart. Acquire samples of equal weight of common pure elements, such as aluminum, copper, lead. Compare the sizes (volume) of the samples. Compare the physical properties. Completely fill three large identical beakers with water. Into one gradually add 100 grams of aluminum, collecting the displaced water in another container. Into the second beaker repeat the process with 100 grams of copper, and the third with 100 grams of lead. Compare the amounts of water displaced. (Refer to Archimedes' principle of displacement.) Relate the amount of water displaced by each element to the arrangement of these elements on the chart.

Topics	*Understandings*	*Suggested Activities*
Table of Elements (Continued)		Repeat the above experiment by using equal volumes, rather than weight, of the samples.
C. Mixtures, Compounds and Chemical Changes	Elements in nature may be found in a pure or combined state. When two or more elements combine chemically, a new type of matter, called a compound, is formed. The compound has new properties and does not resemble any of the elements which have combined to form the compound. When elements or compounds are brought together mechanically, without chemical union, the type of matter called a mixture is formed.	See attached exercise for distinguishing between symbols, formulas, and equations; and for distinguishing between mixtures and compounds. Priestley's Experiment: Heat a small amount of mercuric oxide in the bottom of a dry test tube. Note the grayish film which forms near the cooler top of the tube. Scrape a wood splint around in this film. You will collect a drop of shiny, silvery liquid. This is mercury.
D. Significance of Chemistry in Other Areas of Science	Chemistry works in all areas of life. It is the basis of extensive new studies in other fields of science such as biology, earth science, space, etc.	Have students do literary research on topics of new discoveries, experiments and developments in other fields where chemistry is the basis. (For example: the following may be found in the 1962-63 issues (Vol. XLVIII of Current Science) Space—"Rocket Scrubbing" Metallurgy Bacteria Space Medicine Pollution Light Oil—"Barrel of Magic" (Shell Oil Company, Jackson, also has stage show.)

Topics	*Understandings*	*Suggested Activities*
		Chemistry of Fire—includes an experiment.
		Radioactive Trash
		Other topics for which material is easily found: **plastics** **rubber** **textiles**
		Contact industries in your area for field trips.

Supplemental Exercise for Chemistry Unit

SYMBOLS—Using symbols of the elements, list the gases in air. (O_2, N_2, H_2, CO_2, and minute quantities of others.)

A. Have the gases of the air combined with each other? (Students may answer, "yes," but actually they have not, by definition of mixture and compounds.

Do you find the same amounts of each in the air in all localities? Is there a chemical reaction between these gases? Why?

B. What would you call this combination of gases? (a mixture) Why? (There is no chemical reaction between the gases, and no special chemical process is necessary to return them to an original state. Also varying the amounts of the gases present does not change the fact that it is air.)

FORMULAS—What are the two elements which combine chemically to make water?

C. (Hydrogen and oxygen)

What is the chemist's way of writing water? (H_2O)

What does this way of writing "water" tell you about its chemical nature?

(It is composed of hydrogen and oxygen. It takes 2 atoms of hydrogen in chemical combination with 1 atom of oxygen to make 1 molecule of water.)

(See Unit II)

Chemically, what is water as compared to air? (a compound)

EQUATIONS—Using the information you have gathered from the formula for water,

D. Show how these elements combine mathematically to make a molecule of water. This form of statement is called an equation.

2 atoms of Hydrogen plus 1 atom of oxygen makes 1 molecule of water

$$2H + O \rightarrow H_2O$$

(Important note: Actually oxygen in the air is found in the molecular state, O_2, rather than the atomic, O.)

Other factors and special conditions are usually necessary to complete this chemical combination.

Note the use of the arrow instead of equal sign.

Other chemical processes may be used to reverse this reaction, in which case the arrow would also be reversed.

Another simple equation:

H_2	$+$	Cl_2	$\rightarrow$	$2HCl$
(One molecule of hydrogen)		(One molecule of chlorine)	yields	(two molecules of hydrogen chloride)

UNIT V—7TH GRADE

Topics	*Understandings*	*Suggested Activities*
Unit V—Introduction to Biology A. Basis of Life—The Cell 1. Typical Cell	The cell is the basis of life. Its basic composition is microscopic. It is usually a three dimensional mass of protoplasm surrounded by a cell membrane (wall). Protoplasm is a transparent jellylike substance exhibiting characteristics of life. It is composed largely of such elements as carbon, hydrogen, oxygen, nitrogen, sulfur, and phosphorous, but also contains smaller amounts of calcium, iron, and sodium, and traces of other elements. Protoplasm may be more specifically classified as nucleoplasm, that portion within the nucleus, and as cytoplasm, that portion between the nucleus and the cell wall. Nucleoplasm includes the nuclear membrane, nucleolus, and chromatin.	Filmstrip, "Cells—Building Blocks of Life," list item no. 59. Use models of typical cells. Use charts and drawings of various kinds of cells, such as muscle, nerve, heart, etc. Explain that diagrams and models are representative and not exactly like the actual cell as seen in life. Use egg albumen as an illustration of type of matter which protoplasm is. The egg itself can be used to illustrate parts of the typical cell. Film, "Microscopic Life," item no. 59. Examine ground water samples collected from ditches, streams, etc. for evidence of one-celled life forms. A microprojector is of extra value here as the view may be projected onto a screen which may be observed by the entire class.

Topics	*Understandings*	*Suggested Activities*
Unit V (Continued)		
2. Plant cells	The plant cell is made of the same parts and substances described in the typical cell but with specialized adaptations for plant structures and life processes. The plant cell is surrounded by a cell membrane with the addition of a cell wall, which is quite thick by comparison. The plant cell wall is made of non-living materials. Contained within the cell may be chloroplasts (green chlorophyll) and vacuoles (spaces within the cell). It may contain inorganic crystals. There are other bodies in the cytoplasm which may be left for further study.	Examine the cells of a grapefruit or orange. These are large enough to be seen without the aid of a scope. They are the small juicy sacs which can be separated when the membrane (a tissue) surrounding each section is removed. Use lower epidermal layer of magnolia leaf to make slides for viewing. Locate and identify the structures. Explain why cells, though three dimensional, look flat. Do this by changing fine adjustment on scope. Collect algae from pond for viewing one-celled plant life under microscope or microprojector. Elodea leaves are thin and provide excellent materials for viewing. Protoplasmic streaming may easily be observed in this living material. (Note: If slides are to be used for several hours, it is a good idea to seal the cover glass to the slide by applying melted paraffin with a water - color paint brush to the perimeter of the cover glass. Be cautious in heating the paraffin.

Topics	*Understandings*	*Suggested Activities*
Unit V (Continued)	All plant cells are not alike. Cell structures are varied from the typical in order to serve certain functions within the plant, e.g., leaf cells as compared to root cells.	Using a magnifying glass, carefully study the structures of the top and underneath sides of a leaf. Note the differences. With the help of textbooks and encyclopedias name the parts and tell what each does. Begonia, elm, mimosa, magnolia, and silver maple leaves are easy to obtain and study. Make a cross-section and a longitudinal section of a root. Examine with magnifying glass or under the microprojector. Draw what you see and label the parts. Make a cross-section of the petiole of a leaf. Draw what you see. Label the parts. Cut very thin slices of carrots, potatoes, onions, and apples. Compare the differences between the sizes and shapes of cells.
3. Animal Cells	The animal cell is made of the same parts and substances described in the typical cell, but with special adaptations for animal structures and life functions. As compared to the plant cell the animal cell is surrounded by a cell membrane only and does not contain chloroplasts.	Make contrasts between plant and animal cells. (See teaching aid.) Make slides using epidermal cells scraped from inside the cheek. Stain with gentian violet so nucleus is visible. (Note: staining kills these cells.) Recognize the parts of the cell you see. Learn to spell and understand the appropriate vocabulary.

Topics	*Understandings*	*Suggested Activities*
Unit V (Continued)		Slides may be made of the cells from various organs and cuts of meat and fish. Using the edge of a spoon, gently scrape some cells from the muscle portion or organ tissues. A drop of water, preferably distilled, may be needed to dilute and, therefore, separate the cells for uniform spreading.
		Make slides (or use prepared ones) of blood cells of animals and human. Note the comparisons with the typical cell structure; note the differences.
		As a summary exercise, have students draw, label, and compare the basic characteristics of a typical plant cell and a typical animal cell.
B. Cellular Processes	All cells carry on the following life processes: food getting, digestion, absorption (osmosis), circulation, respiration, assimilation, growth, excretion, secretion, sensitivity, reproduction.	Have members of class prepare a report on how cells and their parts function in living tissues and be able to discuss how their life activities serve as a means of existence.
	Plant cells differ in the food-getting process by manufacturing their own food by means of the process of photosynthesis. Photosynthesis can take place only when chlorophyll is present.	Discuss the process of photosynthesis. Have students draw enlarged cross sections of leaves illustrating location and direction of flow of the plant foods, and cells of different types.
		Fasten some discs of cork to both sides of a green leaf so that part of the leaf is shielded from light. Allow the plant to grow normally for a week in its usual conditions. Remove the pieces of

Topics	*Understandings*	*Suggested Activities*
Unit V (Continued)		cork and dissolve the chlorophyll from the leaf by placing in alcohol overnight. Place a few drops of iodine stain on the bleached leaf. Does the entire surface turn a dark blue-black color? Since the blue-black color is a test for starch, what inference can be made about the foodmaking process and the role of light? Make drawings to show similarities of respiration in plant and animal cells. Demonstrate transpiration by placing a plastic bag over a potted plant. By the use of an egg, illustrate the following life processes: osmosis, assimilation. Remove the shell first by placing an egg in a weak solution of hydrochloric acid, HCL, for a few hours, then rinse thoroughly with cold water. a. Place egg (with shell removed) in a beaker of plain water. Watch the developments. b. Place same egg in a beaker containing a fairly strong solution of salt water. Watch the developments. c. Try placing egg in a solution of colored water for a few hours. Break open and examine contents. Examine membrane under microprojector or widefield reflecting microscope. (Note: As

Topics	*Understandings*	*Suggested Activities*
Unit V (Continued)		long as the membrane is not punctured, the egg will remain in good condition for a couple of days. It keeps better in the salt solution than in plain water.)
		Using text or reference books (and classroom chart if available), have class draw, label, and explain each step in cell mitosis.
		Films: "The Thread of Life." Bell Tel. Co.; "Heredity," MSU Extension. Film List No. 16 and No. 77.
		Using books and charts, study the parts of the typical flower. Then obtain flowers for each student to dissect and locate the parts. Have class draw each part and label.
		Using the parts of the typical flower, explain and distinguish between the following processes: pollination, fertilization, and germination.
		In addition to seed plants, list and discuss other means by which plants are reproduced such as, budding. root cuttings, stem cuttings, runner, grafting, etc. Experiment with above structures, starting new plants.
C. Growth and Development of Cells	All life begins with single cells. In lower forms the new cell may grow only in size before reproducing itself. In high-	Mix molasses and water together until mixture is quite thin. Add a little baker's yeast and stir thoroughly. Allow

Topics	*Understandings*	*Suggested Activities*
Unit V (Continued)	er plants and animals a series of processes known as growth occurs before reproduction.	to stand for about 30 minutes, then examine under low power microscope or microprojector. Count the number of cells. Allow to stand overnight in a warm place. (Keep covered). Now count the number of yeast cells. Compare your results with those of the previous day in number, size, and appearance. Place a planarium (almost microscopic flatworm) in a watch glass with some water. Place watch glass under low power of wide field microscope. With sharp razor cut the planarium in half crosswise. Place watch glass in a cool place. Notice the two pieces each day. What is happening to each half? Are both halves regenerating their lost parts? Study rate of growth in plants. Use plant foods, also plant hormones. The latter are available at most biological supply houses.
	In complex forms of life, cells are specialized. They are grouped to form *tissues.* Tissues are arranged to make *organs,* which are important parts of *systems* of the organism. The *life processes* are the functions of the systems. A study of systems and of the *classification of the forms of life* is left to a later study.	Using a chicken heart, beef heart, or liver, notice the following by dissection. Carefully separate cells and observe how they are arranged to form tissues. Observe the arrangement of cells in the membranes. Continue the study observing the variance of tissues and their arrangement to form the complete organ.

Topics

Unit V (Continued)

Understandings

The sequence of development is constant for all organisms, including man. Only the rate differs from individual to individual or from kind to kind. Of special interest to adolescents is the differences among themselves. These differences are due to a combination of inheritance and environment.

To help the students see the different rates of growth in height in boys and girls of the same age, have all girls of the same age line up against the chalk board and make a mark on the board for each girl's height. Repeat the process for the boys of the same age as the girls in the first group. Draw a line through the marks for the girls; draw a line through the marks for the boys. (Note: each group should have been arranged in ascending or descending order.)

If there are older students in the class, let them make a line to show their differences. This will allow a comparison of boys and girls of the same age; of boys and girls of different ages; and indicate the tendency to growth rates.

Discuss the rates of growth of boys and girls between the ages of 8 and 16 or between the fifth and tenth grades.

Have reports prepared on the life and work of:

(1) Gregor Mendel
(2) Luther Burbank

(Films listed under "Cellular Processes.")

Work problems on simple inheritance. Valuable help on this topic may be found in many new textbooks at junior and senior high school levels.

Topics	*Understandings*	*Suggested Activities*
(Unit V, continued)		
D. Living Societies—Plants and Animals	**All life on earth has been classified into two great divisions, the plant kingdom and the animal kingdom, of which man is a member in the highest form. In order for life to be sustained on earth, a balance between the two kingdoms must be maintained. Such a balance depends upon many factors, which are both biological and physical.**	**Excellent extensive resource material for this unit is included in the conservation kit available from the Mississippi Soil Conservation Service of the U. S. Department of Agriculture, Jackson, Mississippi.** **Collect different plants from fields, ponds, marshes, dry areas, hilltops and hollows, or as many different types of locations as possible. Be careful to tag or label your specimens as you collect them, giving the date, place, description of type of soil, availability of water, sunlight, etc.** **Examine the roots, stems, and leaves for size, shape, and special structures. What adaptations have the different plants made in form to help them survive the conditions of the area in which they live?** **Film, "Simple Plants and Animals," film list item no. 59.** **Make a map of Mississippi. Color in the areas showing the distribution of forests, farmlands, and barren areas.** **Collect lichens (algae and fungi living in a particular relationship). Use an encyclopedia or biology book to find out**

Topics	*Understandings*	*Suggested Activities*
Unit V (Continued)		what these plants are like and how they help each other. Find out also how lichens are used.
		Find out different ways in which seeds are spread. A biology or botany book will help. Collect samples of plants which distribute seeds by the different ways.
		Grow new plants from seeds, cuttings, roots, bulbs.
		Make a report on the cypress tree. Find out what special adaptation it has made and why. If possible, bring a cypress knee to class.
		Collect insects and small animals. Examine the mouth and body parts. What adaptations have the different insects and animals made in order to acquire the food, water, and protection they need?
		List several of the animals which are found in your area. Make a report on the foods and habits of these.
		Write to the Mississippi Fish and Wildlife Service for information on the conservation of birds and wild flowers.
		Make a report on the Audubon Society. Find out their origin and purpose.

Topics

Unit V (Continued)

Understandings

Suggested Activities

The following activities are suggested only as an introduction to this broad area of study.

To illustrate the principle that all forms of life are dependent on other forms and that balance between the areas must be maintained, let interested members of the class make reports on such topics as:

a. rain forests
b. life in the sea
c. life in the arctic
d. life in the antartic
e. comparisons of life between coastal and mountainous regions.

Each of these reports should be kept to a general nature.

Collect information on the distribution of certain animals (such as buffalo, snakes, whooping cranes, bald eagles, etc.) throughout the United States. Explain why they are more abundant in some areas than in others. Why are some animals now extinct? What is being done to keep other previously abundant species from becoming extinct?

Write a report on the migration of birds. Make a poster to show the flyways.

Teaching Aid, Unit V.

PRINCIPAL PARTS OF A CELL[1]

Living Substances:	*Nonliving Substances:*
Protoplasm	Cell Wall
Cytoplasm	Vacuoles
Nucleus	Cell Sap
Cell Membrane	
Plastids	
Mitochondria	

DIFFERENCES BETWEEN PLANTS AND ANIMALS[2]

In the final analysis there are no criteria which enable us to divide all organisms into two clearly defined groups . . . the plants and the animals. The following differences hold true in most cases.

Plants	*Animals*
(a) Have cellulose cell wall.	(a) Have no cell wall.
(b) Have no powers of locomotion.	(b) Have powers of locomotion.
(c) Are less irritable.	(c) Are more irritable.
(d) Grow throughout life.	(d) Grow to a definite size.
(e) Manufacture own foods.	(e) Require complex foods from outside.

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[1] Sam S. Blanc, et. al., *Modern Science 1,* (New York: Holt, Rinehart, and Winston, Inc., 1963), p. 203.

[2] Gordon Alexander, *Biology,* (7th ed.; College Outline Series; N.Y.: Barnes & Noble, Inc., 1959), p. 27.

UNIT VI — 7TH GRADE

Topics	*Understandings*	*Suggested Activities*
Unit VI—The Science of Soil and Water Conservation		
A. Our Lives Depend on Soil and Water	Farmer controls use of soil, water, and wildlife on 85 per cent of U. S. land. All of us are dependent on soil and water for food, clothing, shelter and much of our recreation. Forty per cent will depend on soil for careers. As citizens, we have responsibility.	Make a field trip to study the relation of natural vegetation and wildlife to their environment. Make a cross-reference chart showing the different ways in which soil, water, plants, animals, and man depend on each other. Film: "The Soil and Life," film list item no. 64.
B. What Is Soil? 1. Composition	Soil is the loose surface material of the earth, in which plants grow and on which life depends. It is composed of water, air, the dead remains of plants and animals, and rock materials. Some rock materials are large enough to see, but most are so small that we do not know that they are rock.	Submit samples of important types of soil in your community to a state laboratory for analysis of available plant-nutrient content. (Soils Testing Laboratory, State College, Mississippi.) The student may secure a soil testing kit from Scientific Supply Company and make his own tests. County agent or vocational agricultural teacher may help.
2. Differences	Soils differ considerably. There may be a variety of soils in the same field or lawn.	Test different types of soil for: Water-absorbing and water-holding capacity Rate of capillary movement Texture (separate clay, silt, and sand particles with sieves or a centrifuge machine.) Organic matter Adhesion (a) Effect of organic matter (b) Effect of particle size

Topics	*Understandings*	*Suggested Activities*
C. Soil Erosion 1. Definition—causes 2. Erosion—the principal land problem 3. Erosion in Mississippi	Soil can be destroyed. Soil loss can lead to community loss. Soil erosion can destroy valley land below, rivers and streams, fish and wildlife, flood control reservoirs, town water supplies. Eroded land can be treated. Soil erosion is the wearing away of the surface of the earth by wind and water, and it has already destroyed millions of acres of our most valuable land. It is the principal land problem. Soil is a *renewable* resource, but it takes unaided nature a very long time to build soil. Soil erosion can remove in a few years—and sometimes in a few hours—the surface soil that was formed during hundreds of thousands of years.	Demonstrate the soil-carrying capacity of water flowing at different velocities. Discuss conservation surveys based on soil types, degree of slope of land, degree of erosion, and present use. Land capability maps: Delineate areas of land suitable for the production of cultivated crops, pasture and range, forests, and wildlife. Eight land classes for soil and water conservation: Learn limitations in use and the specific conservation practices required for each class. Obtain charts from Soil Conservation Service, U. S. Department of Agriculture, Jackson, Miss.
D. Good Land Use Conserves Soil	Soil must be kept fertile by use of fertilizer, by crop rotation and by prevention of erosion. In preventing erosion we also conserve water.	Take field trips to observe erosion damage and soil and water conservation practices. Participate in conservation projects.
E. Hugh Bennett—Father of Soil Conservation	First conservation act passed by U.S. Dr. Bennett's theory of land-use a. Theories applied on 247 million acres	

b. 48 countries adopt his ideas

Material may be obtained on other topics of Soil and Water Conservation from U. S. Soil Conservation Service, 490 Milner Building, Jackson, Miss. to develop the following outline:

F. Soil Conservation Districts
  1. Set up under Mississippi law
  2. Progress in Mississippi
  3. How districts work

G. How Mississippi Farmers Plan
  1. How state ranks in production
  2. Land use
  3. Predictions for the future

H. What Will Our Future Needs Be?
  1. Increased demand for water and recreation
  2. Agriculture can meet demand
  3. Mississippi's water rights law

I. Teamwork in Conservation
  1. Small watershed program
  2. Mississippi ranks high in number of applications

J. You Can Study Your Own County
  1. Conservation needs inventory
  2. Conservation problems close at hand
  3. Conservation is a philosophy

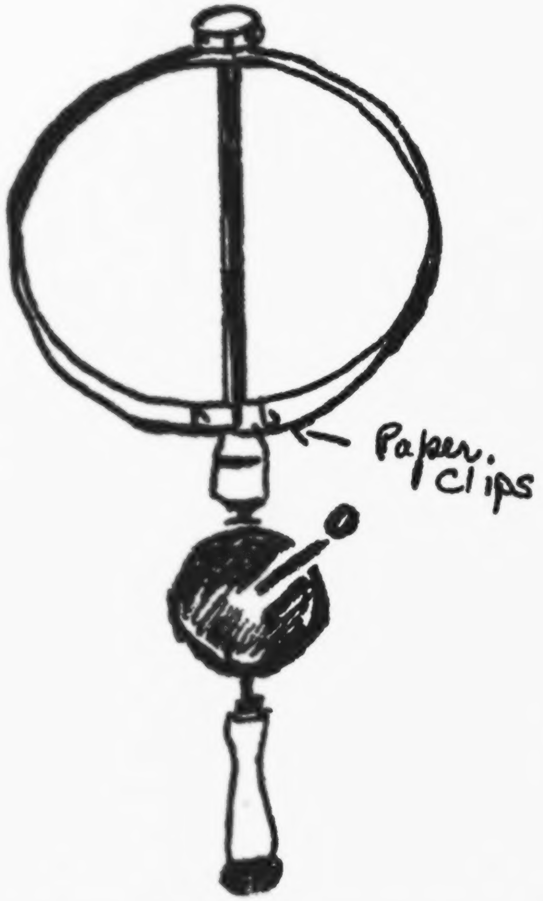
EIGHTH GRADE — FIRST SEMESTER

EARTH AND SPACE SCIENCE

Topics	*Understandings*	*Activities*
I. The Earth A. Location B. Size C. Shape	Earth is the third planet from the sun in the Milky Way galaxy. Earth is one of the smaller planets. Earth is roughly spherical in form. More accurately it is flattened a little at the poles.	The filmstrip, "The Earth in Space," Filmstrip no. 55 will give good background material. Precede the filmstrip by listing facts on the board which the students believe to be true about the Earth. As the topic develops, discuss and correct the errors. Demonstrate the bulging of the earth by means of the hoops on the centrifugal apparatus. Students conduct research on recent findings of the IGY and space exploration which have a bearing on the changing concept of the earth's shape. (Refer to Vanguard I) Work up a set of simple problems involving the calculations of the distance around the earth. Set up a scale which can be used to make a sketch of the earth on the chalkboard, using the different equatorial and polar diameters and circumferences. These figures might be changed to metric for practice and also written in scientific notation. Review 7th grade Unit II. Show flat global maps on the overhead or opaque projector illustrating percentages of solid and water surfaces. Research by the students could be done on the changing balance between the water and land surfaces of the earth in ages past.

References:
The Physical World. Harcourt, Brace, and World. Chapter one.
Earth Science. Singer, Chap. 8.
Modern Science one. Holt-Rinehart and Winston, Inc. Unit four.

Topics *Understandings* *Activities*



Demonstration: Why planets are not spherical.

Centrifugal force helps explain why the earth is flattened at the poles and why the larger planets are still less spherical.

Materials:

- Hand drill
- 2 strips of heavy paper about 1½" wide (manila folder)
- Paper clips
- Dowell about 8 inches long
- Tinkertoy circular joint to fit dowel
- Support for drill

Activity: Make holes in ends of each strip large enough for dowel. Set up as indicated below. Turn the hand drill and note what happens to the strips. How does this principle apply to such things as:

- Clothes dryer
- Washing machines
- Cream separators?

D. Divisions
  1. Lithosphere

Lithosphere, the solid part of the earth, is divided into the crust, mantle and core. Less than 30% of the solid surface is exposed.

Topics

a. Crust

(1) Internal

(2) External

b. Land forms

Understandings

The crust provides man with food, minerals, and shelter.

Internal forces change the surface of the earth.

External forces wear away and tend to level the surface.

Constructive processes build up landforms by earth movements that shape the surface.

1. Mountains
2. Plains
3. Plateaus

Destructive processes sculpture the surface by erosion, producing other land forms.

1. valleys
2. caves
3. cliffs
4. delta
5. bars
6. dunes
7. gulley

Activities

Review of 7th grade Unit II.

Filmstrips which might be used in the area of internal and external features are: "Our Changing Earth," "The Story of Volcanoes," (See Filmstrips under EBF.) "The Story of Mountains," "The Story of Ice and Glaciers."

Demonstrate the surface changes due to internal forces with an inflated balloon covered by sand. Deflate slowly and note the surface changes. Glycerin-potassium-permanganate volcano eruption can be demonstrated as an earth force. Ammonium chloride added to this mixture will give smoke column, or ignite small pile, (one teaspoon) of ammonium dichromate $(NH_4)_2 Cr_2O_7$.

Define these terms:

anticline
syncline
fault
plateau
plain
fissure
seismograph
physiography
diastrophism
earthquake
batholith
dike
mesa
fiord

Discuss these words illustrating by chalkboard sketches, pictures, or models.

Assign reports on:

Stone Mountain, Georgia
Devil's Tower, Wyoming
Mauna Loa, Hawaii
San Francisco Earthquake-1906
Alpine Topography
Mississippi River Basin

References:

Exploring the Sciences, p. 69.
Earth Science, Chapter one, Singer.
Modern Science One, Chapter eleven, Holt, Rinehart, and Winston.

Topics	*Understandings*	*Activities*
c. Theories	Theories advanced to explain these movements are: isostasy contraction convection continental drift See reference (a).	Groups or individuals could select a theory and do the reference work necessary to demonstrate each theory. See reference (b). Challenge the students with the question: "What is Hydrological Decade?" (This study began in 1965).
2. Hydrosphere a. Oceans	About 70% or more of the Earth's surface is covered with water.	Allow students to demonstrate the chemical and physical properties of water (solvent, temperature, expansion, specific heat, others). Show films from the Prudential Insurance Company of America dealing with the Oceans.
(1) Currents	All the forces of the earth stir the seas into ceaseless motion.	Use maps to show and explain the various ocean currents. Discuss the findings during World War II concerning the difference in direction of surface and sub-surface currents in the Mediterranean and Gulf of Mexico. Relate direction of ocean currents to wind direction and Coriolis' Effect. Film: "Unchanged Goddess", Bell Telephone Company, relationship of currents to climates. See Film list, item no. 14.
(2) Minerals	The sea is the storehouse of many minerals.	Assign special reports of the minerals of the sea and how they are "mined". Special note should be given to the need and methods being tried to remove salt from sea water to add to man's water supply.
(3) Life	Our oceans are filled with many forms of living things.	

References:
(a) *Earth Science,* Van Nostrand, pp. 231-276.
(b) *Earth Science,* Singer, p. 28 (isostasy). pp. 175-176 (continental drift).

Topics	*Understandings*	*Activities*
		Discuss: "Why is the surface of the sea saltier in the southern hemisphere than in the northern?" Show ecological relationships of life forms to temperature, pressure, chemical composition, sediment, and wastes from coastal cities.
		Groups of students could investigate topics concerning the life in the oceans: Plants, animals, suitability of environment to life forms, and present findings and projects concerning the increasing of production and utilization of the sea-life. Show filmstrip: "Plants and Animals Under the Sea." Discuss the formation of the coral reefs of the Pacific. Students might set up exhibit of coral.
b. Other Groundwater	Water is stored principally between the grains of rocks and in zones where rock is fractured.	Review 7th grade work on water table and wells, etc., Unit II.
	Groundwater moves by gravity through rocks to the lowest levels of the topography—toward streams and lakes.	Demonstration on Wells Water Table. (See reference (a), and determine degrees of purity of water from various sources. (See reference b.)
		Students should become familiar with terms such as valley, divide, meander, cut-off, tributary, oxbow, floodplain, natural levee, sandbar, delta, etc. Relate to local examples where possible. Groups could study topographic maps to see how running water af-

References:
(a) *Science, A Way To Solve Problems.* MacMillan, p. 330.
(b) *Exploring the Sciences,* Harcourt, World and Brace. p. 241.

Topics	*Understandings*	*Activities*
c. Hydrology	Certain chemical processes change the earth. If bedrock is soluble, as in the case of limestone, it will be dissolved directly by slightly acid groundwater, forming sink holes and caves.	fects contour lines. Do research work on how to determine the characteristics of a landscape succession that includes stages of youth, maturity, and old age. Make local survey of topography, and where interest permits, have models constructed to illustrate findings. Filmstrips helpful are: "The Story of Rivers," "Work of Running Water," "The Story of Ice and Glaciers," and "Our Changing Earth." See filmstrips under EBF.
	Dripstone features in caves (stalactites, helicates, stalagmites, columns, etc.,) are formed when lime-charged water enters caves from ceilings and walls, evaporates and precipitates $CaCO_3$.	Review chemical change from 7th grade Unit IV. Have lab work on reaction of HCl on limestone. Write equations for this reaction. Also try H_2CO_3 as the acid. Interpret equation below in relation to caves and cave deposits. $CaCO_3 + H_2O + CO_2 \leftrightarrow Ca\ (HCO_3)_2$ Ask for voluntary research and exhibits related to famous American caves.
	Water is our most abundant and our most useful liquid. Its role as a solvent and its part in crystallization are only two of the many reasons for its importance.	Discuss how materials are precipitated from water. Students should give demonstrations of these processes. Provide lab activities illustrating: Hard and soft water The effect of hard water on materials How hard water can be softened Make studies of famous caves. Emphasize the chemical processes which caused these formations.

Topics	*Understandings*	*Suggested Activities*
3. Atmosphere Layers	An envelope of gases surrounds the earth's surface. The atmosphere has different characteristics at various levels and is divided into layers accordingly.	Secure samples from several mineral wells or springs. Evaporate equal quantities of the water and compare the amounts of mineral salts obtained. Conduct research for tests which might help identify the minerals. Review 7th grade Unit II.
a. Physical characteristics	Air is a mixture of gases.	Filmstrips which might be used in this area as needed are, "Weather Maps," "Water in Weather," Air in Action," "Thunderstorms," and "The World We Live In." See Filmstrips list—items no. 44, 45, 46, 47.
	Air has weight and exerts pressure in all directions. Air pressure is on the average about 14.7 lbs. per sq. inch at sea level; it decreases as height above sea level increases.	Atmosphere: A. Call for research on the layers of the atmosphere and the preparation of a summary chart or poster to show: 1. Heights of each division 2. Temperatures of each division 3. Special features of each layer 4. Heights attained by airplanes 5. Heights attained by satellites and rockets B. Extra credit for short written description of space, where it is, and how man is affected by "lack" of air. Atmospheric pressure may be explained with the discussion that by starting with a one square inch container at sea level and raising it into the exosphere a column of air would be formed that would weigh 14.7 lbs.

References:
Earth Science, Singer, pp. 202-206.
Modern Science One, Holt, Rinehart, and Winston, Inc. pp. 111-114.
Our Environment series, 8th grade edition.

Topics	*Understandings*	*Activities*
(1) Pressure	Air pressure can be measured by the height of a column of mercury which the air will support or the change in the thickness of an evacuated box (aneroid barometer). Relative humidity can be measured by the wet and dry-bulb thermometer (hygrometer) because the rate of evaporation is largely determined by the amount of water vapor in the air. The pressure of air varies with its temperature.	Illustrate air pressure by putting a card on top of a full glass of water and inverting the glass—why does the card remain on the glass? Tie a piece of cheese cloth securely over a wide mouthed jar. Invert the jar. Why does the water remain in the jar? Demonstrate the barometer as a tool to measure amount of pressure. Observe aneroid and mercurial barometers. Request reports on Torricelli. Make a water barometer by placing a one-hole stopper fitted with a glass tube in a bottle which has about one inch of colored water in it. Blow a few bubbles of air into the bottle, until water rises in the tube. Place a paper marker on the glass tube and note changes in the level of water with changing air pressure. Changes in atmospheric temperature would affect the accuracy of the barometer. Boil about 100 ml of water in a flask. Take flask from flame and cork. When the water stops boiling, place under cold water and it will start boiling again. Discuss this as an illustration of how water will boil at lower temperatures if pressure is reduced. Refer to car radiators boiling in mountains where pressure is less. Research assignment: What changes must be made in recipes for cakes in high altitudes? Why?

References:
Modern Science One. Holt, Rinehart, and Winston, Inc., pp. 118-122.
Earth Science, Singer. pp. 202-212.
Exploring the Sciences, Harcourt, Brace, and World. pp. 154-180.

Topics	*Understandings*	*Suggested Activities*
(2) Temperatures	Temperature is the degree of intensity of heat.	Explain temperature by referring to 7th grade work on the forms of matter and density. (Unit 3)
	Thermometers can be used to indicate changes in temperature because materials change in volume when heated or cooled.	Lab work on thermometers to understand the operation as one of contraction and expansion using a liquid or metal which reacts with even slight temperature changes. A clinical thermometer should be discussed from the standpoint that its bore is not straight as in other liquid thermometers.
		Make a simple air thermometer. Note—Design your own thermometers or refer to the 7th grade course of study.
		Make a water thermometer. Fit a one-hole rubber stopper with a glass tube in a bottle completely filled with colored water so that the water stands about half way up in that part of the tube which is above the stopper. The glass tube should be long enough to extend several inches outside the bottle.
		Have students keep records of pressure and temperature for several days; then, discuss any relationship which seems apparent between the two and explain.
		Demonstrate unequal heating of land and water. Place a dish of soil and another containing an equal weight of water in the sun. Place thermometers in each and measure the changes in temperature during ten

Topics	*Understandings*	*Activities*
Temperature (Cont.)		minute intervals. Conclude which of the materials heats the faster. Have students explain "land and sea breezes" and relate to local experiences. Problem: For a rise of 1500 ft. (near the earth's surface) the temperature drop is about 5 degrees F. A rise of a mile would represent a drop of ________ degrees?
	Thermometers based upon the metric system use the Celsius (Centigrade) scale. Other scales include Fahrenheit and Kelvin (absolute). Temperatures can be converted from one scale to another.	Demonstrate in the lab how the various types of thermometers operate; also, the hygrometer and barometer. Determine freezing and boiling points of water using ice and a heat source. Illustrate to the students how to convert Centigrade to Fahrenheit and vice versa. Solve problems using formulas demonstrated. Review the water cycle as presented to the 7th grade in Unit II. Demonstrate the dew point by forming of "dew" on a glass of ice water in a warm room. Include the fact that condensation occurring below the freezing point is frost. The freezing unit of a refrigerator is an easily observable example of this. The principle of "Saturation" can be illustrated with a sponge and water.

References:
Earth Science, The World We Live In, pp. 432-448.
Basic Earth Science. Singer. pp. 210-211.
Modern Science. Holt, Rinehart, and Winston. pp. 114-118. 165-167.
Modern Science One. Holt, Rinehart, and Winston. pp. 143-145.
Earth Science, The World We Live In. Van Nostrand. pp. 482-490.
Basic Earth Science. Singer. pp. 216-229.

Topics	*Understandings*	*Suggested Activities*
(3) Humidity	Humidity is the water vapor in the air.	Students should observe weather reports on T.V. and in newspaper for the relationship between temperature, relative humidity, clouds and forms of precipitation.
	The amount of water vapor in the air is called absolute humidity.	
	The amount of water vapor in the air compared to the amount of water vapor it could hold when saturated is called relative humidity.	Lab Activity: Determine Relative Humidity both by the dry and wet bulb method and by the dew point method.
	Warm air can hold more water than the same volume of cold air can hold before it becomes saturated.	
	Clouds are formed as moisture laden air cools below the dew point and are visible as suspended in the air.	Weather maps can be made on sheet metal and weather symbols attached to small magnets for easy arrangement by students.
	Conditions necessary for cloud formation: 1. vapor present 2. charged particles upon which vapor condenses 3. change in temperature 4. saturation	Demonstrate the formation of a cloud by placing several tablespoons of rubbing alcohol in a jug; attach vacuum pump with one hole stopper and tube; pump some air out; then suddenly remove the stopper. Cool alcohol vapor inside meets inrushing warm air and condenses into visible cloud. Explanation of why the cloud forms should be left to the students. Cloud and fog formation are examples of saturated air.
	Different forms of clouds are associated with different kinds of weather. (See reference a.) P. 114	
	Moisture which condenses and falls from the air is called precipitation.	Make a Cloud: Place a small-mouthed jug in a refrigerator. Leave overnight. Remove the stopper. Blow quickly, warm, moist breath into the jug. Then restopper.
	The forms of precipitation are: rain; snow; sleet; hail.	

Topics	*Understandings*	*Activities*
		Illustrate cloud types by chalk board sketches, filmstrips, or pictures. Specify heights at which each is found, shapes, color, whether formed from ice crystals or minute water droplets and relate weather conditions. Study clouds by observing and recording cloud types over a few days time.
		Show symbols for clouds as used on weather maps.
		What is the relationship between fog and smog? What is the economic importance of smog?
		Boil water in a pan to use in illustrating evaporation, condensation.
		Place cool glass plate over pan and note drops which form. Question the group as to the conditions necessary to form snow flakes. Have students determine difference in the way sleet and hail are formed.

References:
(a) *Exploring the Sciences.* Harcourt, Brace, and World. p. 148.

Problem: How big is a rain drop?

Material: Rain
Pie pan or paper plate
Cover for the plate
Flour sifter or small strainer
Flour
Ruler

Activity: (Naturally this cannot be done unless it is raining.)

Sift about ½ inch of flour into the plate.
Cover the plate.
Go out into the rain.
Uncover the plate for three seconds. (Long enough to say one thousand one, one thousand two, one thousand three.)
Cover the plate immediately.
Go inside.
Uncover the plate.
Allow the lumps (which are flour particles soaked up by raindrops) to dry. This may be several hours or the next day.
Measure the lumps by carefully drawing a line at each side of the lump and measuring the distance between the two lines.
Measure all the drops you have.
Are they all the same size?
What is the average size?
Make a chart of these facts.

Conclusion: Is this an accurate measure of a raindrop? Explain.
Can you suggest other methods of measuring rain drops?
What additional facts might be interesting for a study in regard to rain drops?

Topics	*Understandings*	*Suggested Activities*
(b) Air mass	The masses of air surrounding the earth are continually shifting and changing. The daily changes in the conditions of the atmosphere constitute the weather.	Outline on maps or on the chalkboard the air masses of North America and the direction of their movement. Teach the symbols used for each mass:
	Air masses are either polar or tropical, depending on their origin. Their movement is affected by temperature difference and the prevailing winds.	Maritime polar—mP Continental polar—cP Maritime tropical—mT Continental tropical—cT
(1) Front	A front is the boundary between two air masses of different characteristics. These are: (1) cold (2) warm (3) occluded (4) stationary	The film "Unchained Goddess" will provide excellent information as an introduction to weather or as a summary at the end of the topic. See film list, item no. 14. Introduce the U. S. Weather Bureau symbols for the weather fronts as used on weather maps. Clip successive daily weather charts from the daily newspaper showing fronts and characteristic weather for frontal systems.

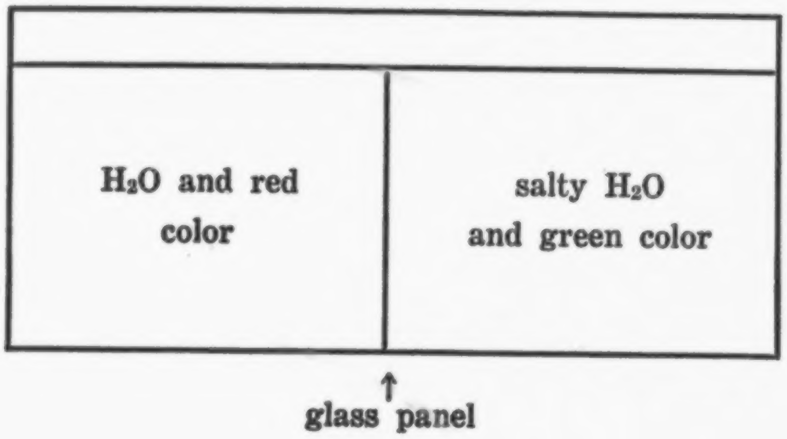
References:
Basic Earth Science. Singer. pp. 216-218.
Modern Science. Holt, Rinehart and Winston, Inc. 172-176.
Exploring the Sciences. Harcourt, Brace, and World, Inc. pp. 145-146. 148, 150.

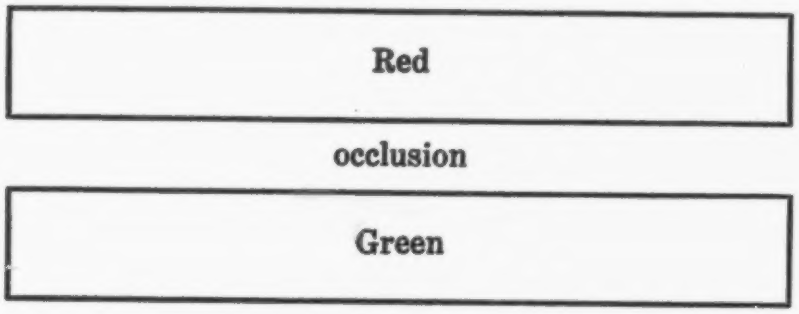
SPECIAL LAB EXERCISE

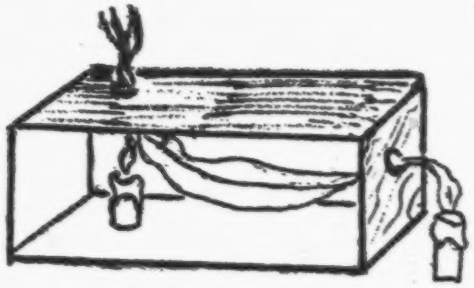
Unit I Earth and Space Science

Occluded Front

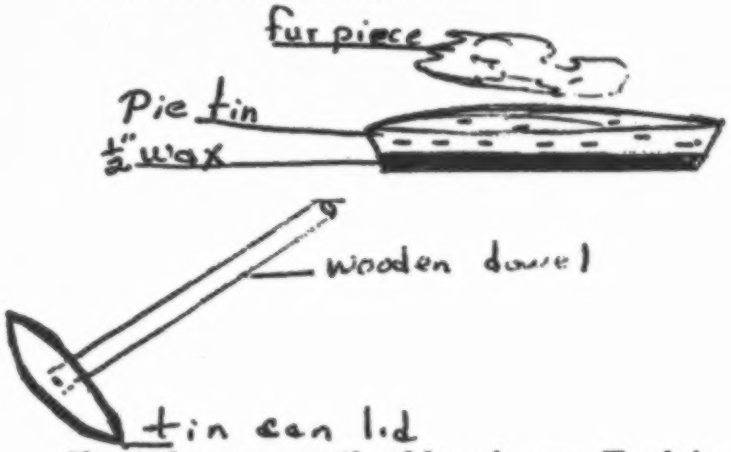
Take a small rectangular jar or small aquarium; place a clear glass section to divide into half. Fill with water and heavily salt one section of the water. Put red food coloring in one end, green in the other. Stir quickly and remove the glass section. Observe the occlusion in color.


H_2O and red color
salty H_2O and green color
glass panel


Red
occlusion
Green

Topics	*Understandings*	*Activities*
(2) Winds	The rising warm air and sinking cold air form convection currents. Wind is the movement of heavier air into a low pressure area. Temperature differences plus the earth's rotation are primary factors affecting wind direction. A mariner's rule is: Face the direction from which the wind is blowing. Your right hand will point to the center of the low. Explain.	Demonstrate effects of heating and cooling air, using a convection box. To make a convection box: Obtain an empty shoe box. Remove the cover of the box. Cover the top with cellophane, fastening it into place with Scotch tape, as shown in the accompanying diagram. Cut out one end of the box to make a hinged door. Set the box on its side and place a short candle inside. Cut a hole the size of a quarter over the candle, and another one the same size in the lower part of the door of the box. Light the candle, close the door and seal the joints. Dampen a paper towel slightly. Set it on fire for a moment. Blow out the flame and it will give off smoke. Hold the paper near the hole in the door. The movements of the smoke will show the movements of the air. 
(3) Storms	Thunderstorms come from cumulonimbus clouds with swiftly rising air currents. Such clouds develop electric charges that produce lightning. Thunder is a result of a sudden heating of air by lightning. A tornado is a powerful whirlwind that usually travels toward the northeast. The center of the tornado is a very low pressure area.	

Ref:
Modern Science, Holt, Rinehart, Winston, Inc.; 160-166, 172-178
Basic Earth Science, Singer, 214-216, 244-148.

Topics	*Understandings*	*Suggested Activities*
Storms (cont.)	Hurricanes are also intense low pressure wind storms. They form in tropical and subtropical regions.	Assign reference work on the cause of hurricanes, tornadoes, and water spouts. Diagram the pressure areas and differences which are represented in a storm. To get an idea of whirling movements of winds around the eye of a hurricane, fill a sink with water. Remove stopper and observe whirling motion of the water. Demonstrate lightning by building an electrophorus as follows: Pour a wax layer 1/2 inch thick in the bottom of a metal pie pan. Fasten the top of a large tomato can to a dowel rod handle with a nail. Rub the hardened layer of wax with a piece of fur or wool. This will produce a negative charge on the surface of the wax. Touch the wax with metal on the dowel and with a finger at the same time Remove both, now bring the metal near a finger of the opposite hand and a spark can be seen and heard.  fur piece Pie tin ½" wax wooden dowel tin can lid Chart the mean path of hurricanes. Explain. Make poster of newspaper articles on death and damage caused by lightning.

Topics	*Understandings*	*Suggested Activities*
(4) Weather forecasting	From early times, man has been concerned about the weather and has attempted in many ways to control or predict its changes. Reliable weather forecasts depend on evidence obtained by accurate measuring instruments. Recording is done with symbols, on charts called weather maps. Within the past three hundred years, man has made great progress in his efforts to understand how changes in the atmosphere bring about changes in the weather. Weather factors are responsible for color phenomena in the atmosphere; such as rainbows, twilight, cloud color, sunset, color of sky, star twinkling.	Give the students mimeographed U. S. outline maps, weather information for the various parts of the country and have them make their own maps, using the symbols from the U. S. weather maps previously introduced. Overhead projector may be used to show maps. A local weather station may be established, using simple commercial weather recording instruments or home-made equipment such as milk cartons, paper, rubber sheet, pins, etc. If possible visit a weather station such as the one at the new Jackson Airport. Have class report on the significance of these terms: meteorologists psychrometer radiosonde anemometer radar isobar almanac Make any of these as science projects: rain guage anemometer psychrometer water thermometer

References:
Modern Science One, Holt Rinehart, and Winston, Inc. pp. 178-183.
Basic Earth Science. Singer. pp. 218-223.

Topics

(C) Climate

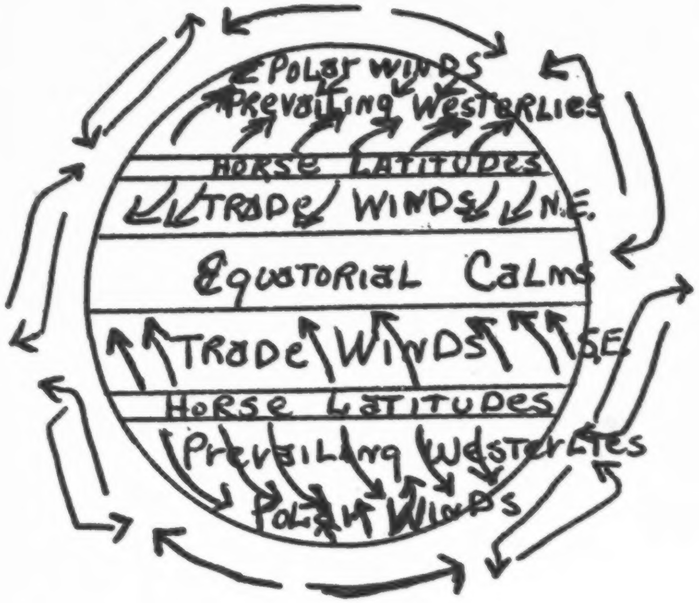
Understandings

Climate is the total weather at a certain place over a long period of time.

Some factors which influence climate are:

- prevailing wind
- ocean currents
- mountains
- angle of sunlight (latitude)

Climate affects the distribution of plants and animals over the earth.



Suggested Activities

Discussion topics:

(1) Reasons for different climates in various parts of the earth. Include such factors as:

- sea level altitude
- distance from oceans
- distance from mountain regions
- location in regard to prevailing winds or storms (latitude)

(2) Effect of climate on the economic life of various regions

Demonstrate the effects of slanting and vertical rays by arranging three shallow pans of earth so that one is on top of a box and the other two slanting from table top to box top on an incline. Place the arrangement in the sunlight in a window. Have a thermometer in each pan and record the temperature at the end of 5, 10, and 15 minutes. Determine which pan is warmest. Change the position of the pans. Then after some time, record the temperatures again. How is this demonstration related to the change of seasons?

Assign a report on Alexander Humboldt. Discover what he had to do with climate.

List evidences we have that the earth's weather has changed. How has it affected history?

Using a globe, explain latitude. How are climate and latitude related?

List the characteristics which a plant must possess in order to live in a tropical climate, a polar region or climate.

References:

Modern Science One. Holt, Rinehart, and Winston, Inc. pp. 184-189.
Basic Earth Science. Singer. pp. 39-42.
Earth Science, The World We Live In. Van Nostrard. pp. 532-537.

LAB ACTIVITY

Problem: How does the angle of radiant energy affect the temperature?

Material: Black paper, cardboard 8 cm by 30 cm, tape, thermometer, metric ruler, scissors, heat lamp or 200 watt light bulb, aluminum foil for reflector, two ring stands or some upright support, clamps for ring stands, and protractor.

Activity: Cover the card board with black paper, using tape. Place two strips of tape at the bottom of the cardboard and attach it to the table as a hinge arrangement. Attach a reflector to the upright support (with the light source inside the reflector, of course). Place the light source 80 cm from the board. Tape the thermometer to the board. Divide the duties of the group as follows:

Timer who will indicate 2 minute intervals between "ON" and "OFF"; light switch operator who carries out the timer's orders; thermometer observer who records the temperature at the beginning of "ON" period and at the end. First timing is done at a 45 degree angle then at 90 degrees, and then flat. Now move the lamp up to 40 cm from the board and repeat the two positions and readings of temperature. BE SURE TO ALLOW THE THERMOMETER TO COOL TO ROOM TEMPERATURE BETWEEN EACH READING INTERVAL. After the experiment is complete, find the amount of temperature gain for each angle and distance. Make a chart showing distance, angle and gain.

Conclusion: How does the angle vary with the temperature? Is the distance related to the temperature change? How does the seasonal change in earth temperature relate to this experiment? If the earth were not tilted as it now is, what change would occur in the earth's temperature? Which do you feel has the greater effect on the temperature, distance or angle? How can you substantiate this with examples from the earth's temperature?

Extra Activity: Conduct the same experiment with solar radiation. Compare your findings and see if the conclusion is the same. Use shadow measurement to determine the earth's change of angle over a period of one month. Report your findings to the class.

Topics	*Understandings*	*Suggested Activities*
E. Age 1. Geological time	A geological time table shows the relative age of rock units and fossils over the earth.	Discuss the meaning of such terms as era, eon, epoch, fossil, geology, paleography, archaeology. Students may conduct research including charts and illustrations of these topics: formation of fossils, use of index, fossils, determining past climates, radioactive "clocks," and half life, characteristics of the era in which fossils occurred.
a. Crystozoic Eon b. Phanerozoic Eon (1) Paleozoic era (2) Mesozoic era (3) Cenozoic era	By analysis of radioactive minerals in fossils, geologists have been able to set the key dates in the geological time table.	
	Fossils are remains of organisms or evidence of their presence preserved from prehistoric time.	Show film: "Fossil Story". See film list item 17. Have students arrange an exhibit of local fossils, and try to determine their place in the geological time table.
	Eras are divided into periods, each covering several million years.	
II. The Sun—Our Star A. Size	The sun is a star of medium size. It has a diameter of 864,000 miles, and from earth it appears larger than other stars.	Plan a field trip to observe interesting local formations. (rock quarry, road cuts, or outcropping of fossil rocks)
B. Composition	The sun is a glowing globe of gas with a density 1.4 times that of water.	Show the film: "Our Mr. Sun" from Bell Telephone Company. Measure distance from the earth to the sun. See reference (a).
C. Temperature	The external temperature of the sun is a few thousand degrees F, but physical forces cause the internal temperature to be about 200,000 degrees	See film list, item No. 15. Research: What is a star? Let students propose possible means for finding the elements or compounds contained in the stars. Give a hint by burning certain substances in a Bunsen flame such as salt, sulfur, baking soda; observe color in darkened room. Make a simple spectroscope. See reference (a). Develop the understanding of the reasons for the difference in the internal and external temperature of the sun.

References:
(a) *Earth Science, The World We Live In.* p. 346.
Modern Science One. Holt, Rinehart, and Winston, Inc. Chapter two. pp. 30-35.
Basic Earth Science. Singer. pp. 310-316, 285-292.

Topics	*Understandings*	*Suggested Activities*
D. Energy Source	The energy radiated by the sun comes from internal nuclear fusion. This process is slowly exhausting the nuclear fuel.	Demonstrate the heat of compression by using a bicycle pump to force air into a ball, tire, etc. Review concepts of energy. Discuss the sun as the chief source of all energy. Have students prepare charts showing the conversion and the utilization of the sun's energy. (Refer to Telstar, photosynthesis.) General Electric, Bell Telephone, and General Motors offer materials for demonstrations and exhibits.
E. Surface Features	Sunspots appearing on the surface of the sun are caused by solar flares affecting large areas and altering the temperature. Streams of bright gases extend outward from the sun's atmosphere and are called prominences. The sun may be studied by areas such as the photosphere, chromosphere, and corona. Tongues of electromagnetic fields extending throughout the solar system from the sun have been discovered by the space explorations.	Materials on electro-magnetic fields extending from the sun can be obtained from Bell Telephone Co., "Ferro-Magnetic Domains." See film list, item No. 10. Refer to sunspot facts from previous film, "Our Mr. Sun." See film list, item No. 15.
III. Solar System A. Theories of Origin	The structure of the solar system reveals clues to its origin. Clues to the origin of the solar system have evolved several hypotheses. Theories of origin: Nebular hypothesis Planetesimal Protoplanet	Discuss the theories of origin. Why were some proven inadequate? Suggest that students do research on theories of origin. Show filmstrip "Earth is Born."

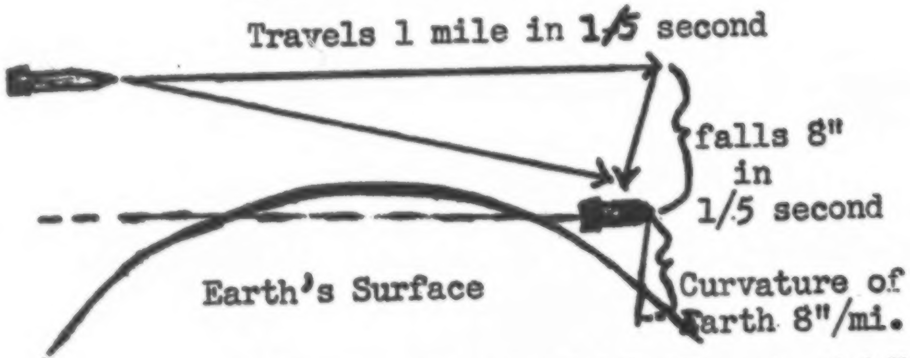
References:

Modern Science. Holt, Rinehart, and Winston, Inc. pp. 28-30, 30-35.
Basic Earth Science. Singer. pp. 285-307.

Topics	*Understandings*	*Suggested Activities*
B. Planets	The solar system is mainly composed of nine planets orbiting around the sun in nearly the same plane, moving in the same direction, west to east, with varying eccentricity of orbits.	Show filmstrip: "Sun and Its Planets." See filmstrip No. 39. Students report on Galileo.
1. Comparative sizes and positions	Planets are grouped into major and minor, according to size. Planets are grouped into inner and outer, according to their position relative to the asteroid belts.	Students prepare brief oral presentation of the planet they would most like to visit, giving reasons. Report on Mars as photographed from the Mariner 4.
2. Relative distances from the sun	Distances from the sun to all planets are too vast to comprehend except by comparison. Kepler's Laws: (1) The orbit of each planet is an ellipse in which the sun is at one of the two foci. (2) Each planet revolves so that a line from the planet to the sun sweeps over equal areas in equal times. See reference (a).	Have students bring in objects showing relative sizes of the planets, and arrange according to distance from the sun. Space students on playground, relative to planet positions. Have students write the distance to the various planets, using scientific, mathematical notation.
3. Natural satellites	A satellite is an attendant body maintaining an elliptical orbit around another body. To understand why satellites go around the earth and stay in orbit requires a knowledge of two basic principles. The first of these is simple *inertia,* the tendeny of a body to remain in motion unless acted upon by some outside force.	Bode's Law mathematically predicts a planet between Mars and Jupiter. Is there one so located? Illustrate Kepler's Law. Use a spool through which you insert a string with small ball on one end, large ball on the other end. This device should be whirled in such a manner as to cause the lighter ball to circle over your head, pulling the heavy ball up or down. Explain role of each article in this activity.

References:

(a) *Earth Science, The World We Live In.* p. 364.
Modern Science. Holt, Rinehart, and Winston, Inc. pp. 35-48.
Basic Earth Science. Singer. pp. 329-331, 334-337.

Topics	*Understandings*	*Suggested Activities*
Planets (continued)	The second has to do with the *pull of gravity*. There is a tendency for the satellite to be drawn back to the earth, but the earth's surface has a curvature of eight inches/mile. If an object can be made to go a mile horizontally in the time gravity makes it fall eight inches, the object will be no closer to the earth at the end of the mile than it was at the beginning. This is exactly what happens to a satellite traveling about five miles per second in an orbit a few miles above the earth. *It falls around the earth.* Speed: 5 mi. a second  Travels 1 mile in 1/5 second falls 8" in 1/5 second Earth's Surface Curvature of Earth 8"/mi. Satellite is in state of fall. The rate of fall and forward motion act to keep satellite in orbit.	
a. Phases	As the moon revolves around the earth it shines only by reflected light and presents phases of varying lighted portions when viewed from the earth.	Phases of the moon are not real, but apparent. Use chalkboard sketch to demonstrate this point. See the filmstrip, "Earth's Satellite, The Moon." Demonstrate with light source and balls. See filmstrip No. 41.
b. Eclipses	A lunar eclipse is caused by the earth's coming between the sun and the moon, casting a shadow on the moon.	Demonstrate the viewing of an eclipse indirectly by projecting an image on a piece of paper through a pin hole.

Topics	*Understandings*	*Suggested Activities*
Planets (continued) c. Tides	Tides are caused by the gravitational pull of the sun and the moon on the waters of the earth. The rising and falling of the earth's ocean waters are its tides.	Demonstrate by using two styrofoam balls. Use a large and a small one. Also use a filmstrip or a movie projector as a light source. When can eclipses occur?
4. Gravitational attraction	Newton's Law: Everybody in the universe attracts every other body with a force which varies directly as a product of their two masses and inversely as the square of the distance between them.	Demonstrate the way the moon rotates on its axis by having a student walk around an object designated as the earth. Note that the student keeps one side toward the earth. Recall that this also applies to Mercury's revolution around the sun. Students may conduct research on low, high, neap and spring tides. Note: Investigate tides as: a source of energy; commercial uses; cleaning factors in oceans. Demonstrate with the feather and guinea tube. Set up problems from theoretical or actual examples and have the students calculate the velocity or speed of fall by formula. $g = 32$ ft./sec./sec. $v = gt$ Discuss the differences in gravity on the various planets and show how this would affect "jumping." (Track records. See end of unit.) Summarize the importance of gravity in the structure of the solar system. Attach figures to the globe with rubber cement or clay and spin the globe to show how the figures are held to it. Discuss escape velocity as related to planets. (7 miles a second, or 25,000 miles per hour on the earth)

References:
Modern Science. Holt, Rinehart, and Winston, Inc. pp. 22, 44-45, 384.
Basic Earth Science. Singer. pp. 149, 150, 252, 253, 291, 400, 350-364, 348-351.
Earth Science, The World We Live In. Van Nostrand. pp. 365-366, 386-421.

Topics	*Understandings*	*Suggested Activities*
5. Revolutionary and rotational movement	Revolution is the movement of a body in its orbit around another body, a movement about a point (center of revolution) outside the body under consideration. Rotation is the turning of a body on its axis.	Use a small model planetarium to demonstrate the principles of revolution and rotation. Spin a top to demonstrate earth's motions. Where a planetarium is not available, have a student demonstrate the two principles by turning around where he stands for rotation and walking around his chair for revolution. Stress that a complete rotation of the earth requires a day while a complete revolution requires a year. Contrast the Ptolemaic and Copernican Systems.
a. Units of time	The units of time are hours, minutes, seconds, days, weeks, months, and years. Longitude may be expressed in degress, hours, minutes and seconds.	Using a globe, discuss the degrees, hours, minutes and seconds involved in time keeping. (Learn the terms longitude, prime meridian, chronometer, sextants). Students may work simple problems of distance in degrees and related time. (15 degrees = one hour, basis of time zones)
b. Time belts	Regions of the earth running north and south use the same standard time throughout.	Discuss time belts of the world and learn to make time changes from one belt to the other. Also introduce the concept of daylight saving time and explain how it further alters time. Activity Time Belts (See end of unit.) Have a student explain the armed forces method of reporting time. Show how time is related to problems of

References:
Modern Science. Holt, Rinehart, and Winston, Inc. pp. 22, 36-37, 48-54, 55, 51-52.
Basic Earth Science. Singer. pp. 279-281.
Earth Science, The World We Live In. Van Nostrand. pp. 402-421, 394, 422, 428.

3

Topics	*Understandings*	*Suggested Activities*
Revolutionary and rotational movement (continued) c. International date line d. Calendar	The International Date Line is an irregular line approximately along the 180th meridian, fixed by international agreement, as the place where each calendar day first begins. A calendar is a schematic system of recording large areas of time, based on the revolution and rotation of the earth.	navigation. Relate the navigational uses of the chronometer, sextant, and compass. Student might construct a simple "anglefinder" to use at home in locating the North Star at night. Show how the international date line is indicated on the globe. Note it is not straight. Discuss the reason for this. Topics for discussion and research may include: the *Aztec calendar*, the *Roman calendar* and the presently used *Gregorian calendar*. Challenge questions: "What is the World Calendar?"; "Why do two consecutive years not begin on the same day?".
e. Seasons	The seasons of the year are determined by the position of the earth's axis in relation to the sun. Inclination of the earth's axis causes a change in length of days, and a change of the angle of the sun's rays, both affecting temperature.	Students may develop skit to present facts. Use a planetarium to show the movements and inclination of the earth which cause the seasons. If this is not available, demonstrate with a flashlight and a globe. Show a filmstrip: "Why the Seasons?". See filmstrip no. 42. Define and demonstrate the terms vernal and autumnal equinox, summer and winter solstice. Use a globe to show the equator, the tropics of Cancer and Capricorn.

References:
Earth Science, The World We Live In. Van Nostrand. pp. 422-429.

Problem: How we can measure the pull of the earth

Materials: 15 pennies

Ruler with both English and Metric units
Pencil (six sided)

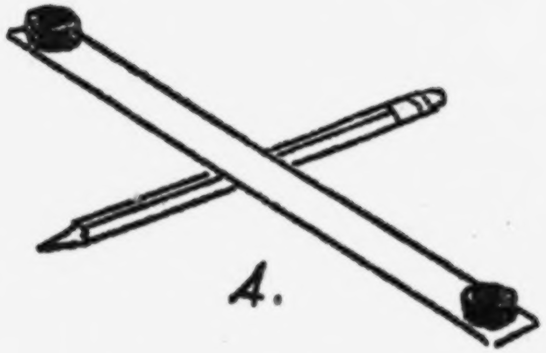
Small objects, light in weight (bottle top, eraser)

Activity: A. Place the center of the ruler over the pencil at right angles to the pencil.

Place the object to be weighed on one end.

Add pennies to the other end until it is as nearly balanced as possible.

How can this principle be used to make a scale to give known gram weight?



B. Place the pencil under the 8 cm mark.

Place eight pennies on the long end.

Determine how many pennies will be needed to balance the eight pennies.

Sketch a scale which might use this principle to weigh objects in grams.

Which scale would be best suited to small light objects?

Why?

Which scale would be best suited for heavy objects?

Why?

Where have you seen such scales? List several of each.

Why was this lab lesson titled "How we measure the pull of the earth"?

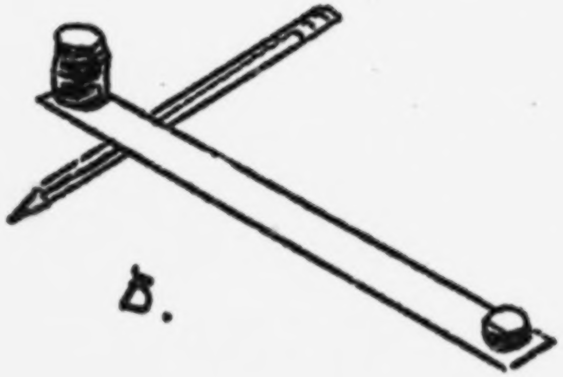


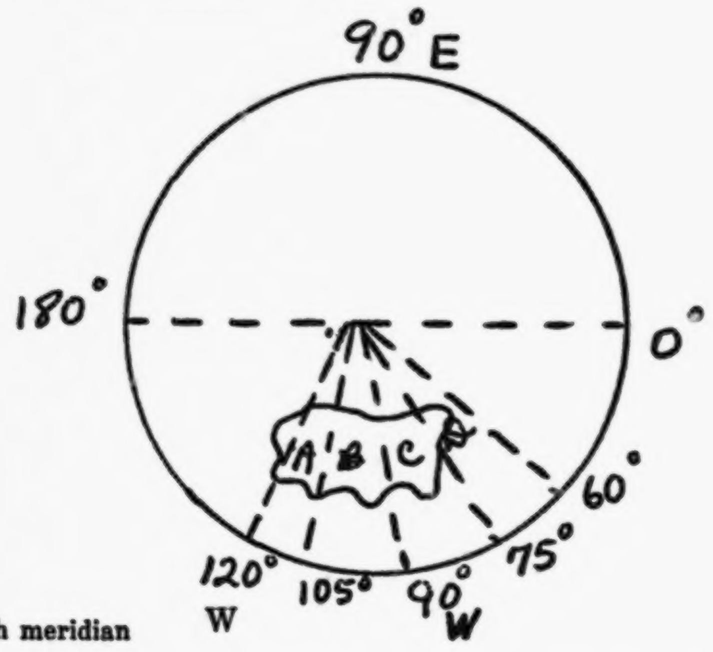
TABLE OF GRAVITY CORRECTION FACTORS FOR OLYMPIC RECORD KEEPERS

Latitude degrees	Javelin throw	Broad Jump	Shot Put
90	+24.47	+2.47	+5.64
70	+19.80	+2.00	+4.37
60.2 (Helsinki)	+14.15	+1.43	+3.26
52.3 (Berlin)	+9.00	+0.91	+2.07
50	+7.24	+0.73	+1.67
48.88 (Paris)	+6.40	+0.65	+1.48
41.9 (Rome)	+1.77	+0.18	+0.41
40 (Columbus)	0.00	+0.00	+0.00
37.7 (Melbourne)	–1.60	–0.16	–0.37
34.1 (Los Angeles)	–4.13	–0.42	–0.95
20	–12.35	–1.25	–2.85
10	–15.97	–1.61	–3.68
0 (Equator)	–17.23	–1.74	–3.97

Application: Some athlete using the same amount of energy would throw a javelin a shorter distance at Helsinki than Columbus due to the pull of gravity. Therefore, add 14.15 centimeters to the Helsinki score.

TIME BELTS — U. S.

A- PST
B- MST
C- CST
D- EST



Sun directly over 90th meridian

1. The irregular lines on the map represent the adjustment in time belts to consider preference of towns and railroads.

   (a) What time is it in chicago? (CST)____________

   (b) What time is it in New York? (EST)____________

   (c) What time is it in Denver? (MST)____________

   (d) What time is it in Los Angeles? (PST)____________

2. What time will you see a T.V. program in Los Angeles if it is shown in New York at 8 P.M.?

3. If you call a relative in Chicago at 9 P.M. his time, what time should you place the call from your home in Seattle?

4. What time will you arrive in Dallas, Texas, if you board a plane at 8:40 A.M. in New York for the 2 hour and 15 minute trip by jet?

INTERNATIONAL DATE LINE

The International Date Line is the place where travelers set the day forward if traveling westward and backward if traveling eastward. If it is Sunday on the east side, it is Monday on the west side of the International Date Line. When it is midnight at the International Date Line, it is noon at the prime meridian.

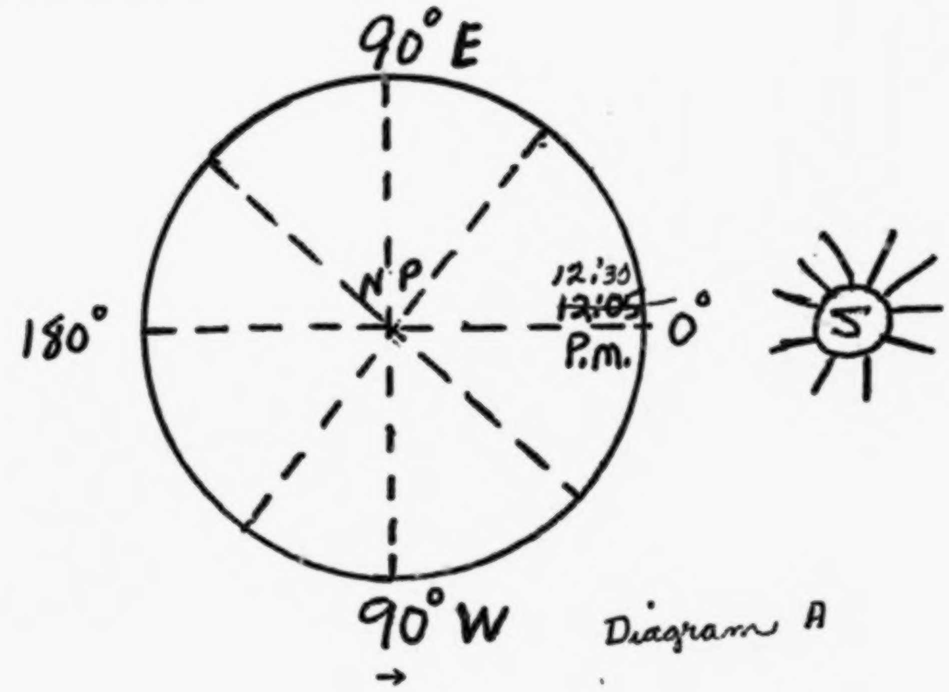


Diagram A

1. **30 min. past noon at prime meridian = ... at the international Date Line.**

2. **On the diagram above write in the time at each meridian when it is 12:38 P.M. at the 0° meridian.**

3. **Shade the part of the diagram that is the new day between midnight and International Date Line. How old is the new day?............**

Topics	*Understandings*	*Activities*
IV. The Stars A. Composition	The composition of stars varies. Largely, they are composed of hydrogen, helium, and some metals.	Review what is known of hydrogen and helium as to their properties and structure. See 7th grade course of study.
	Stars produce their own heat and light. The matter composing stars varies in density. The mass of stars may be as little as 10 per cent of the sun's mass or up to 100 times the sun's mass.	Research: How many elements have been identified in the sun's spectra? How was this determination made?
		Discuss and use chalkboard sketches showing the meaning of density in a comparative sense as in the three forms of matter. Introduce the astronomer's tools such as: the telescope, transit, and spectroscope. Students can learn through research about these tools. A good source is the IGY pamphlet "The Planet Earth", furnished by the National Science Foundation.
		Plan night observation groups with students, if a telescope is available. Demonstrate the principle of the spectroscope, using a prism. Review related light concepts from 7th grade course of study.
B. Size	Stars vary in size from 30,000 miles in diameter to 2,500 times that of the sun.	Develop the idea of macro sizes by comparison of stars to known objects. Introduce this with the question: "How big is a million?" Have students listen to a watch tick for a specified length of time; then, state that if you listen to the tick of the watch for four days and four nights that would be approximately a million ticks.

References:
Earth Science, The World We Live In. Van Nostrand. pp. 321-335.
Science, A Key to the Future. MacMillan. pp. 268-276.

Topics	*Understandings*	*Activities*
Size (continued)		Size might also be shown comparatively by having students construct a circle to cover an 8½ inch by 11 inch sheet of paper. Place one pencil dot in this circle to represent the vastness of the sun against the smallness of the earth.
C. Magnitude	The apparent brightness, or magnitude of stars is used as a means of classification. The *Doppler effect* is used to show the motion of stars and that the universe is expanding. The ancients divided the stars into six magnitudes, with the brightest being the first magnitude. (Subsequent classifications have made use of the — sign for the very brightest)	Through library research, study: the apparent brightness of stars; the age of stars; the way in which temperature of stars is measured, including the instruments used as well as the units; the Doppler Effect; stars that are visible for a particular season; location by constellation.
D. Temperature and color	The brightest stars in the sky in order of magnitude are: Sirus, Canopus, Alpha Centaur, Vega, Capella, Arcturus, Rigel Procyon, Achernar, Beta Centaura, Altair, Betelgeuse, Alpha Crucis, Aldebran, Spica, Pollux, Antares, Formalhaut, Deneb, and Regulus. The surface temperature varies from a few thousand degrees F. while the internal temperature may be almost 200,000 degrees F.	Temperature should be defined as the average kinetic energy of molecules in a body. Demonstrate: temperature color (See reference a.)
E. Location and distance	Distances of celestial bodies can be measured by observing their parallax (apparent displacement).	Demonstrate *parallax* in the following way. Place students A and B in back corners of a room. Have student C stand about 10 feet in front of A and B to form a triangle. Student D should walk a circle route at the front of the room noting the apparent displacement of student C in relation to students A and B.

References:
(a.) *The World of Matter-Energy*. Harcourt, Brace, and World. p. 430, 440, 443.
Modern Science One. Holt, Rinehart, and Winston. pp. 64-68.
Basic Earth Science. Singer. pp. 310-316.

Topics	*Understandings*	*Activities*
F. Motion and effects		Using the chalkboard, illustrate parallax further. Work out a simple problem to show the mathematical approach.
G. Constellations	Constellations are groups of stars forming patterns.	
H. Galaxies	Galaxies are enormous systems of stars. The Milky Way is an example.	Show the filmstrip: "Stars and Galaxies" or other similar material. See filmstrip no. 40. Use sky charts to locate the constellations visible at the present season of the year. Encourage the students to check at night to find these constellations. Study the mythological background of the names of constellations and bring up the question of why these apparent forms do not appear the same now as they did to the ancient Greeks. Note that constellations are important mainly because they make location of celestial bodies easier. Magnitudes of stars in a particular constellation can be identified by the use of terms such as Alpha, Beta etc. For example, the brightest star in the constellation, Lyrae, is called Alpha Lyrae. Beta Pegasae is the second brightest star in Pegasus. Students should write their addresses in the Universe to include their galaxy.

References:
Earth Science, The World We Live In. Van Nostrand. pp. 335-346.
Modern Science. Holt, Rinehart and Winston, Inc. pp. 69-73.
Basic Earth Science. Singer. pp. 308-316.

Topics	*Understandings*	*Activities*
Galaxies (continued)		Plan student research to secure information on the various galaxies. Present this to the class, with supplementary materials such as illustrations, etc. Have students write a description of their galaxy. Introduce the idea that the large "astronomical units" are essential to the scientist who deals with celestial distances.
I. Other bodies 1. Comets	Comets are thought to be composed of rock fragments, ice and gases. They have highly eccentric, elliptical orbits.	Information concerning comets, meteors, asteroids and nebulae may not be found in texts. Research methods will have to be used, as well as any illustrations and charts the teacher has available. Filmstrip: "Comets and Meteors". See filmstrip no. 43.
2. Meteors	Meteors are heavenly bodies which glow for a moment as they pass through the atmosphere, "shooting stars".	Assign reports on meteorites (fallen meteors), some of which are now in museums.
a. Composition	Meteors vary in size and are composed mainly of rock, iron, and nickel.	
b. Origin	Meteors are thought to come from the belts of asteroids or from the tails of comets.	
3. Asteroids	Planetoids, or asteroids, are small bodies of rock orbiting, between Mars and Jupiter, around the sun.	

References:
Earth Science, The World We Live In. Van Nostrand. pp. 347-364.
Basic Earth Science. Singer. pp. 19, 306-308.
Modern Science. Holt, Rinehart, and Winston, Inc. pp. 45-47.

Topics	*Understandings*	*Activities*
Asteroids (continued)		
a. Composition		
b. Origin		
4. Nebulae	**Nebulae are flowing masses of gas and cosmic dust appearing as "holes" in fields of stars.**	**Review the basic laws of motion to insure understanding of inertia. (7th grade)** **Demonstrate the laws of motion.** **Discuss seat belts and their value.**
V. Space Exploration **A. Satellites and rockets** **1. Types of rockets**	**The principle of the rocket is based on Newton's third law of motion: every action has an equal but opposite reaction.** **Present day rockets are modern versions of a very old idea.** **Rockets are classified by the type of fuel used, as well as by the number of stages.** **Rockets are used to launch satellites and ballistic missiles. To do this, the rocket must overcome the force of gravity and the resistance of the air.** **Escape velocity - 7 miles per sec. - is the speed necessary for a rocket to overcome gravity of the surface of the earth.**	**Discussion topics may include:** **the history of rockets;** **types of fuel, their advantages and disadvantages.** **Use oral reports and bulletin board displays.** **Introduce trajectory, parabola, hyperbola in discussion of the launching of rockets. Use chalkboard sketches to clarify.** **Have student demonstrate and explain the various stages of a multistage rocket launching, using models; explain why stages are necessary.**
2. Launching rockets	**Rockets are most effectively launched in the direction of the earth's rotation.** **To remain in orbit, a satellite must have enough orbital velocity to balance "centrifugal force" (or inertia) with the earth's gravity.**	**Discuss the question: How much bonus speed is gained when a rocket is launched in the direction of the earth's rotation?** **Review the diagram of free fall, studied under gravitational attraction of earth.** **Discuss factors affecting the attainment of escape velocity and orbital velocity.**

References:

***Modern Science I*, Holt, Rinehart, & Winston, Inc., pp. 77, 87, 88, 181-182.**
***Basic Earth Science*, Singer, pp. 337-340, 369-377, 379-382, 410-423.**

Topics	*Understandings*	*Activities*
A. Sat. & rockets (cont.) 3. Tracking Rockets	Telemetering is the process of tracking a satellite from earth by the radio signals sent from its instruments.	Have students look in periodicals for setup used for astronauts' flights. Explain to the class.
		Obtain tapes from radio stations of those parts of astronauts' flights which reveal telemetery.
4. Rocketry Problems (a) Force	The forces acting upon a rocket in flight are thrust, drag, lift, and gravity (Newton's 3rd Law)	Construct a simple device illustrating thrust, such as: inflated balloon released with escaping air, CO_2 cartridge in tube, or small model.
(b) Fuels		Discuss dangers of amateur rocketry.
	Rocket motors are simple combustion chambers in which fuel burns and the hot gases given off move backward with force.	
	Rockets use solid or liquid fuel.	Discuss why the oxidizer is very important to the proper development of thrust.
	Solid fuels have been combined with oxidizers making for ease of burning and, safe storage, although the steady burning is difficult to control.	Exhibit on the overhead projector sketches of liquid and solid fuel engines. Discuss differences.
(c) Gravity	Liquid fuels must be fixed with the oxygen in the combustion chamber. The burning is easy to control.	Use match and lighter to differentiate between the characteristics of solid and liquid fuels.
	The excessive acceleration necessary to attain orbital velocity creates problems for the person in the satellite.	Introduce the term "g's" as a special topic. See reference "a" for laboratory exercise on gravity.

References:
a. *Exploring The Sciences*, Harcourt, Brace, & World, Inc., p. 71.

Topics	*Understandings*	*Activities*
A. Sat. & Rockets (cont.)	The acceleration due to gravity is known as "g".	Review the formula for acceleration of falling bodies. Plan simple situation problems for the student on acceleration. Discuss the term "deceleration" and what it means to a space traveler. Figure weight increase or decrease one would experience in space, resulting from acceleration or deceleration.
B. Space Problems for Man 1. Weightlessness	Weightlessness is a state resulting from the balance of gravitational force with force of motion.	Students should determine all the ways in which weightlessness would affect a space traveler. Determine how astronauts are trained to adjust to this unusual physical state.
2. Temperature and pressure	Abnormal temperature variations and decreasing air pressure create physical problems for man in space.	Review the temperature of the surface of the moon. Explain the effects of releasing pressure on the body. Review concepts of pressure and their relationships.
3. Food	Other serious problems in space are: the securing, storing and consumption of food and water; the disposal of waste.	Suggested discussion topics are: overcoming the problems of temperature and pressure extremes in space; the meaning and significance of the terms "roll," "pitch,", "yaw," and the problems they present to the astronaut; the solution of problems related to food in space.

Ref: *Modern Science II*, pp. 274-281.
Basic Earth Science, Singer, ch, 15, 335, 370, 391.
Modern Science I, Holt, Rinehart & Winston, Inc., pp. 95-96 and pp. 149-154, 373-374, 23-24, 378-379.

Topics	*Understandings*	*Activities*
B. Space Problems for Man (cont.) 4. Radiation	Without the protective layer of atmosphere man is exposed to ultra-violet, X-ray, and cosmic rays from space.	
	The zones in space known to contain dangerous radiation have been termed Van Allen radiation belts.	Use a chart to show the difference in the wave length of X-ray, ultra violet ray, cosmic ray, and visible light.
		Assign certain students to obtain additional information on recent studies of the Van Allen belts and to construct a model as a visual aid.
		Obtain charts and pictures of the interior of satellites, showing the complexity of instruments.
		Relate problems to aviation fundamentals and to navigation.
optional *C. Survey of artificial satellites 1. Communications	Man-made satellites are science "laboratories" in space. Satellites like "Telstar" are used as a means of bouncing radio signals back to earth.	Create a chalkboard chart of the satellites in space, giving their distinguishing characteristics - purposes, speed, height, and age. Have students collect information on space flight and arrange a display.
2. Weather	Satellites radio back weather information from space with instruments like thermistors, which measure temperature.	

*Note: It would be possible in some classroom situations to divide the materials contained in this unit, assign to groups, and with a minimum of teacher activity, have the unit taught by the students.

Ref: *Modern Science III*, Holt, Rinehart, Winston, Inc., pp. 374-381.
Modern Science I, 94-100.
Basic Earth Science, Singer, 369-398, 416-423.

Topics	*Understandings*	*Activities*
C. Survey of artificial satellites (cont.)		
3. Observation	Information regarding the detection of radiation - magnetic lines of force at all altitudes and the effect of space travel on animals and man have been secured by special instruments in satellites.	

EIGHTH GRADE—SECOND SEMESTER

LIFE SCIENCE

Topics	*Understandings*	*Activities*
UNIT I - LIVING THINGS A. The nature of living things	Living things are made up of units called cells.	Review the 7th grade unit of work on the typical cell.
1. Physical Basis of Life	Protoplasm is the living substance from which all cells are made. Protoplasm is made up of proteins, which are complex chemical compounds of C, H, O, N, P, and S.	Discuss chemicals from which proteins are formed. Write the chemical formulas for a few common proteins and discuss the components. Egg Albumin: $C_{696}H_{1125}O_{220}N_{175}S_8$ Milk Casein: $C_{708}H_{1130}O_{224}N_{180}S_4P_4$ Haemoglobin: $C_{3032}H_{4816}O_{872}N_{780}S_7Fe_4$ Note the similarities in these proteins.
	Carbohydrates are the chief sources of energy for the cells.	Study formulas for carbohydrates such as: starch: $(C_6H_{10}O_5)_x$ simple sugar (*monosaccharide*): $C_6H_{12}O_6$ double sugar (*disaccharide*) $C_{12}H_{22}O_{11}$ Review oxidation. Note that the waste materials CO_2 and H_2O can be readily formed from carbohydrates. Energy is released. *Testing for the presence of protein and carbohydrates* Suggested materials to test: various kinds of milk (canned, powdered, fresh) chewing gum fruits bread potatoes

References:
Modern Science One. Holt, Rinehart, and Winston, Inc. pp. 198, 200, 202.
Life Science. Van Nostrand. pp. 58-62.

Topics	*Understandings*	*Activities*
The Nature of Living Things (continued) 2. Typical cells	Cells have definite patterns of structure, according to their purposes. Cells are structurally composed of: a cell membrane; cytoplasm; and near the center, a nucleus, which controls the cell activities. Some living things are made of one cell, while others may be composed of millions of cells.	Tests: *Proteins* Add a few ml. of concentrated nitric acid (HNO_3) to the material to be tested. Heat. A yellow color indicates the presence of protein. *Carbohydrates* (a) a starch: A dark blue color appears when a few drops of an iodine solution are added to a substance which contains starch.
3. Life functions	All cells have definite life functions: 1. Food getting and use 2. Oxygen getting and use 3. Movement 4. Growth 5. Reaction to stimuli 6. Reproduction	(b) sugar: To the material to be tested, add one or two ml. of Fehling's solution or Benedict's solution. Heat gently. Different colors, depending on the kind and quantity of sugar present, will develop. Make labeled drawings of typical plant and animal cells. Indicate the structures that are present in one but absent in the other.
4. Biographies	Dedicated men of science often endure hardships because of their new ideas. All discoveries are built on the work of others. As the science of biology advances, so do many other areas of scientific knowledge.	Assign reports on Hooke, Harvey, Leewenhoek, Schleiden and Schwann to show their contribution to biology.

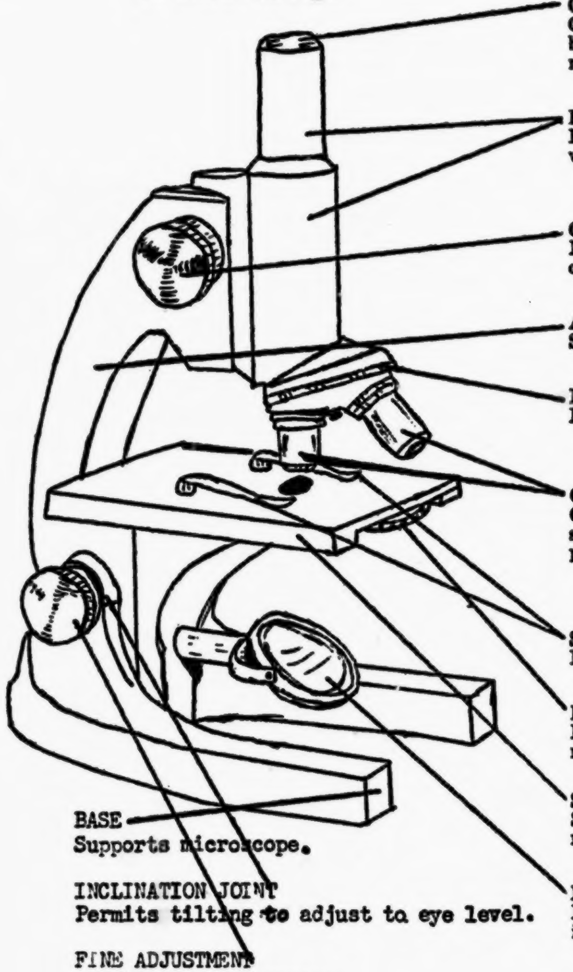
References:
Life Science. Van Nostrand. p. 28-34.

Topics

The Nature of Living Things (continued)

5. Microscope

Understandings



OCULAR
Contains lenses to increase magnification; it may be replaced with another of lower or higher magnification.

BODY TUBE
Holds lenses of ocular and objectives at the proper working distance from each other.

COARSE ADJUSTMENT
Moves body tube up and down approximately to the correct distance from the specimen.

ARM
Supports body tube and coarse adjustment.

NOSEPIECE
Permits interchange of low-and high-power objectives.

OBJECTIVES
Contain lenses of different magnifications; here the shorter, low-power objective is 10X, the longer, high-power objective is 43x.

STAGE CLIPS
Hold specimen slide firmly in place.

DIAPHRAGM
Regulates amount of light passing through the specimen.

STAGE
Supports slide over hole that admits light from mirror below.

MIRROR
Reflects light upward through diaphragm and hole in stage.

BASE
Supports microscope.

INCLINATION JOINT
Permits tilting to adjust to eye level.

FINE ADJUSTMENT
Permits exact focusing.

Activities

Compare and contrast the work of: biologists; geneticists; botanists; zoologists; entomologists; other life scientists.

Study of the microscope

(1) parts:
    location
    purpose
(2) use
(3) care
(4) description of early models

Special assignment: Construct "water drop" microscope. Observe the fundamental concepts of magnification.

Observe typical plant and animal cells, using microscope and microprojector. (onion cells and cheek cells stained with methyl blue)

Proper techniques in operating the microscope may be enhanced by familiarizing students with the names of plants, their functions and operations.

Use microviewer to study cell structure and mitosis.

Topics	*Understandings*	*Activities*
B. Life Functions of Animals	Living things differ from one another in the way life functions are accomplished and in specialization of body parts. The structure of animals shows how life functions are adjusted to environment.	Prepare an outline for the study of selected characteristic animals, according to life functions. (Animals to be studied may vary by group, instructor, and interest.) Suggestions:
1. Kinds of life functions		1. Amoeba and paramecium 2. Hydra 3. Earthworm 4. Crayfish 5. Insect 6. Frog Introduce the study of each animal with a simple, clear lecture, followed by a question and answer period. To develop and expand the outline, plan for student research. Include: location of specimens, references to be used, field study, recording of data, correct procedures in handling a given organism.
2. Specialization of body parts		Follow each research phase on an organism with a laboratory period, which has been well planned. See suggestions at the end of the unit. Augment lectures and research periods with demonstrations to clarify processes such as osmosis.

References:
Science, A Key to the Future. MacMillan. Activity 3. p. 450.

Topics	*Understandings*	*Activities*
Life Functions of Animals (continued)		Review tropisms in animals and plants. Illustration: negative phototropism of paramecium. Stress the value of careful observation. Plan experiences testing students' observation of animals for structure or behavior. Invite a local veterinarian to discuss diseases common to man and dog. Ask local pest control company to talk on roaches or termites, bring films, and/or supply booklets. Have a 4-H student display and discuss his insect collections. Show the film: "The Rival World." See film list, item No. 20.
3. Adjustment to environment		Project - Assign insect collection to be used in classification work. Prepare the student for this work by instruction on how to kill, mount, and preserve insects properly. Direct the students to prepare a summary chart of facts about the animals studied, emphasizing the differences occurring, as one proceeds from simple organisms to complex ones.

Chart for Recording Data of Animals Studied

Name	Vertebrate Invertebrate	One or Many Celled	Respiratory System	Circulatory System	Body Covering	Move-ment	Food Getting

Topics	Understandings	Activities
C. Life Functions of Flowering Plants		
1. Roots	The roots of plants anchor them to the soil, absorb water and dissolved minerals. Water and dissolved minerals are taken in through the root hairs by a process called osmosis.	Have students plant radish seeds in preparation for observation and study. Plant some on small squares of sponge sitting in a small tray of water, some on blotting paper between small squares of glass, and some in small cartons of peat moss or fine soil. Plant beans in jars next to the glass with moist paper backing them; also, plant some in small plastic fruit baskets and some in moss or fine soil held in a paper cup or carton.
2. Stems	Stems hold plants up to the air and sunlight. They serve as a transportation system between the roots and leaves, carrying water, dissolved minerals, and food.	
3. Leaves	Leaves make the food that plants need and give off excess water in the form of water vapor. Green plants almost exclusively have the ability to manufacture food from raw materials.	Appoint committees to care for the plants and assign each a project. In setting up the projects, discuss the problems to be studied and the way the data can best be collected. Emphasize the need for a control. Add a control to each project. Projects for the root committee: Grow radish seeds until small roots and root hairs appear. Furnish the group with plants to study under magnifiers and to sketch. Have them point out features of interest in root study. Prepare sketches of tap and fibrous roots, as well as tubers. Use these sketches in presenting facts about the types of plant roots.

References:
Science, A Way to Solve Problems. MacMillan. p. 44.

Topics	*Understandings*	*Activities*
4. Food making	The process of food making in green plants is called photosynthesis. Plants make food from carbon dioxide of the air, water and dissolved minerals from the soil, through chlorophyll present in the cells, using the energy of sunlight. Oxygen is the by-product of this process.	*Chemical equation for photosynthesis* $6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$ (Carbon dioxide) + water $\xrightarrow[\text{sunlight}]{\text{chlorophyll}}$ sugar + oxygen Project: Jot down a list of foods you have eaten today. Opposite each item in your list, try to trace each food to its source. Ex.: milk cows in dairy. Cows eat grass and grain which grow in the soil, using water, sun, and air. (This project will also show that the sun is the ultimate source of all energy.) See reference a.
5. Seeds	A seed is a complex structure that is capable of growing into a new plant. Many seed plants have flowers to help in the production of seeds. Pollination and fertilization take place before seeds can form.	Take control and experimental set of seedlings from the group planted between glass and invert the experimental ones to show the class what happens to root directions (tropism). Explanations should be prepared to be presented after the rest of the class has had time for their own hypotheses. The root group should demonstrate how roots actually absorb water by hollowing out part of the center of a carrot, filling it with sugar, supporting it upright in water. Compare after 24 hours with the control carrot (no sugar) in water and call for a hypothesis. The stem committee could have these projects done: Study stems of several plants and

Reference
a. *The World of Living Things*
Hancourt, Brace, and World p. 286.

Topics	*Understandings*	*Activities*
		present findings to the group with the aid of large charts or board drawings along with stem specimens. (Structure, growth rings, leaf scars, terminal bud scars, etc.)
6. Tropisms	Parts of plants respond positively or negatively to factors of their physical environment.	Illustrate how stems are affected by the plant's need for sunlight. Place a control plant in a carton, with only a small hole for light to enter, and compare it with the control plant. Discuss this as a type of movement of the plant and give any additional information the group can obtain.
		Stem reaction to gravity may be shown by inverting a plant between two panes of glass for a few days. Use a control plant. How do these effects compare with those of the root group?
		Show the transportation function of the stem by placing celery stalks in a solution of colored water. Observe the movement of water through the stalk.
		Draw cross sections of stem in enlarged detail. Compare with sections examined under magnification. (Use microprojector, microscopes, or hand lens.) Members of the group can present their findings and call for confirmation by the class after they have examined similar sections.
7. Leaf	The structure of a leaf shows special adaptation for photosynthesis.	The leaf group will be interested in presenting the function of a leaf as a manufacturer of food, or food factory.

Topics	*Understandings*	*Activities*
	Transpiration is necessary in aiding the photosynthesis process.	1. Draw microscopic cross sections of leaves to explain how photosynthesis takes place.
	Plants have special features or structures which show adaptations for the regulation of transpiration, according to the availability of water in the natural environment.	2. Place a plant in the dark for several days. Carefully observe and compare to the control. Test for starch before and after exposure to darkness. Compare results obtained.
		3. To illustrate transpiration, cover the soil around a potted plant with foil. Place the plant in a bell jar. Seal with vaseline. Observe the moisture which collects.
		Compare with the control, which consists of a container of covered soil without a plant. Compare the amounts of water given off by geranium, begonia, and cactus to show structural and environmental differences.
		Make a list of local plants and their structural adaptations to environment.
		4. Special project: The skeletonizing of a leaf. This will show vein structure and illustrate the food chain at the same time. Use a magnolia leaf; place it in a tray that is low and long, filled with pond water containing infusoria. After placing in several leaves, keep the tray in a warm place, but not in the direct sunlight. After two weeks the mass of tissue should slough off under running water. Carefully dry between paper towels and bleach with hydrogen peroxide or leave as is.

		Laminate between plastic to keep. The food chain illustrated is: bacteria feeding on leaf tissue; protozoa feeding on bacteria.
8. Flowers	The flower is a specialized part of a plant for the production of seed.	Present the parts of a typical flower on the overhead projector, building up the steps in producing the seed as you go along. Have student fill in the names and functions of the parts on mimeographed sheets previously prepared, with skeleton drawings. Show filmstrip on cross pollination.
	Flowers may be complete flowers, or may lack some parts. If one of the most essential parts is lacking (pistil or stamen), then we would expect to find the counterpart on another flower on the same plant, or on a different plant.	Collect and study parts of different flowers.
		Special outside work: Make a collection of compound and simple leaves. Mount and label. Make a dish garden of beet and carrot tops. Pineapple also might be used. Start cuttings of easily grown, foliage plants. (coleus, geranium, ligustrum) Make terrarium in glass container. (See teaching aid) Start bulbs growing and learn something of the parts.

Topics	*Understandings*	*Activities*
		Do research on grafting and consult an authority. Try a graft with directions from the authority.
		Contact your 4-H or demonstration agent to talk to you about plants in your community's economy.
		Invite a plant pathologist from a local chemical company to talk about the types of research being done to help plant growers.
		Have students plan and carry out research on tropisms of plants. Make a chart of the findings for display.

Problem: Determining the sugar content of chewing gum.

Material: Five types of gum (one should be bubble gum).
10 test tubes
Heat source
Benedict's test solution
Test tube clamp and test tube rack
Watch

Activity: Divide the pieces of gum in half.
Be sure each piece is the same thickness and same length and width.
Place each half in a test tube and mark the type of gum on each.
One set should be put away for part (B).

Part A: Add just enough Benedict's solution to cover the gum.
Heat gently until it has boiled well. Set aside in a rack.
After all samples have been heated, place them in order from most vividly colored to the least vividly colored.
Record the order and give the type of gum. The most vividly colored contains the greatest amount of sugar.

Part B: The problem: How does chewing affect the sugar content of gum?
Use the other set of samples.
Before testing, have one person chew a piece of gum for one minute. Be sure the tester rinses his mouth carefully between samples.
Now test the samples as before.
Arrange the pieces of gum in order of color and attach names as you record.
Compare findings in part A and part B.

Conclusion: Is there any difference in the findings?
If differences are found, how do you explain them?
Can you think of any conditions which could be changed to make the experiment more reliable?
Correlate the findings to advertisements for chewing gum.

LAB EXERCISE

TOPIC: FOOD CHAIN

Balanced aquarium

Gallon jug

Granite chips, washed thoroughly. Use enough to cover the bottom of the jug when laid on its side.

Plants—2 or 3 water plants from pet store or from local ponds.

Fish—a small gold fish or a guppy.

Wooden blocks to hold jug in stationary position on its side.

Put in the washed granite chips. Place the plants in the granite layer (use long tongs or bent clothes hanger). Add water to as near the top as possible and allow it to set for 2 or 3 days to condition the water. Add the fish. Seal the jar. Secure jug in position on its side. Keep air space as small as possible at the top. This aquarium can be kept successfully for several months.

SIMPLE TERRARIUM

Jar—a wide mouthed mayonnaise jar or glass cookie jar.
Moss—turf about 2 inches or more thick
Small animal—a small lizard or other small terrestrial animals
Plants—small fern, or other small green plant

Place turf in bottom of jar. Water it adequately but not too much. Put animal in the terrarium. Top to the jar need not be sealed because it will have to be removed to feed the animal. Do not leave the terrarium in the sunlight or near other heat source. Light in the room will be sufficient to keep photosynthesis processes in operation.

Turtle Terrarium-aquarium

Glass tank—allow one square foot for every 2 inch leave out turtle.

Water—enough for the largest turtle to be completely submerged. Some species feed only under water.

Arrange so that the turtles can climb completely out of water if they want to. Temperature of water should be kept between 75 and 85 degrees F. Water may range from 65 to 90 degrees F but extremes should be avoided. Controlling the water temperature may be helped by a gooseneck lamp with a 40 watt bulb over the aquarium end. Check the temperature daily.

Sunlight is essential for growth of a turtle's shell and to control growth of algae. Shade must also be provided so the turtle will not become overheated.

Glass cover over the container will keep out the dirt. Saran-wrap or plastic can also be used as long as it is not tightly fastened. Air must have reasonable circulation.

Granite chips or sand can be used in the terrarium. When sand is used it should be baked at 350 degrees F for about 15 minutes to kill bacteria or algae. Rocks should be thoroughly cleaned.

Turtle feeding will contaminate the tank. If possible, the turtles should be fed in another container; if not, be sure to clean the tank after feeding.

Avoid temperature changes in adding water.

Feeding must not be more than 2 or 3 times a week. Food should be chopped into small pieces. Prepared food is not adequate. The following is a good turtle diet and should be varied from time to time:

Cod liver oil or bone meal
Flies
Hamburger
Oatmeal
Lettuce, if carefully washed.

Hibernation will be discouraged if (1) no place to hibernate is available, or (2) turtles are kept at uniform temperature all year.

If turtles' eyes close, it indicates lack of sunlight, or poor dirt and low temperature.

Fungus can be killed by putting turtle in solution of one tablespoon of salt to one gallon of water for one hour.

Topics	*Understandings*	*Activities*
UNIT II - INTERDEPENDENCY OF PLANTS AND ANIMALS		
A. The Oxygen Cycle	Plants and animals set up a cycle based on the exchange of carbon dioxide and oxygen.	Review previous work on oxygen and carbon dioxide cycle.
B. Photosynthesis	Green plants make the food for animals through a process called photosynthesis.	Set up demonstration to show that people exhale carbon dioxide and that green plants give off oxygen in the presence of light.
	Animal wastes provide the soil with needed minerals lost in plant growth, erosion, etc.	a. Blow breath in lime water.
		b. Place an inverted funnel over elodea or other water plant. Collect the gas given off in a test tube by displacement of water.
C. The "Food Chain"	Plants and animals independently and dependently set up a "food chain" wherein the larger eats the smaller, or the smaller may be parasitic on the larger.	Carry out experiment of sealing water plant, snail, and water in test tube to prove the interdependence of plants and animals.
		Students may observe and report on food chain in pond or stream, aquarium, certain areas of ground, etc.
		Review ideas on energy with application of the law of conservation of energy to the energy exchange between plants and animals.
		Have student reports on the world's food supply as a social and economic problem of great importance in the present day world, and what is being done to solve this problem.

Topics	*Undersandings*	*Activities*
		Help students develop understanding of how geography, economic conditions and educational level affect world food supply.
		Prepare bulletin board of articles from current newspaper and magazines, concerning world food supply.
		Let students propose possible solutions to the food supply problem and allow class to evaluate each proposal. Test any proposals which bear testing.
		Show "Our Mr. Sun" from Bell Telephone Company. — (Source of energy of our food supply) See Film list, item No. 15.
		Special report on symbiosis and ecology.
UNIT III—HOW LIVING THINGS ARE CLASSIFIED		What would happen if one species became extinct.
A. Classification	All living things are classified into a carefully planned system so people all over the world can identify and study them.	Coronet film "Plant and Animal Communities—The Changing Balance of Nature"
1. Planned System	Animals are grouped by similar characteristics (homologous structure).	Review the earlier study made of Carlus Linnaeus. See teaching aid at end of unit to introduce unit.
2. Homologous structures	The animal kingdom is divided into large groups called phyla.	Assign additional reference work on classifications and find names of other scientists contributing to work on classification.
		Discuss factors which might help determine animal grouping. List several plans and discuss the limitations and merits of each. (Hint: aquatic, terrestrial, vertebrate, invertebrate.)

Topics

3. **Major divisions and subdivisions**

Understandings

Phyla groups are subdivided into:
1. Kingdom
    2. Phyla
        3. Classes
            4. Orders
                5. Families
                    6. Genera
                        7. Species

Classification of Three Familiar Forms of Life

	Man	*Cat*	*Dandelion*
1.	Animal	Animal	Plant
2.	Chordata	Chordata	Spermataphyta
3.	Mammalia	Mammalia	Dicotyledones
4.	Primate	Carnivora	Componulales
5.	Hominidae	Felidae	Compositae
6.	Homo	Felis	Laraxacum
7.	sapiens	domestica	officinale

The scientific name is composed of the genus and species name. Genus comes first, capitalized, followed by species not capitalized. Example: Cat is Felis domestica. Man is Homo sapiens and dandelion is Laraxacum officinale.

Activities

List some classifications of plants based on use, environment, habitats or features other than structure.

Outline on board the present classification system (kingdom, phyla, class, etc.)

Investigate changes which have been made in classification systems through the past. Introduce names of phyla and help students learn something of meaning of the names and their derivation.

Augment discussions on animal groups with filmstrip series on "Structure of Living Things."

Help students work out classification of a few familiar living things such as dog, cat, horse, man. See teaching aid.

Develop an understanding of how scientific names are determined. Ask students to learn scientific names of two familiar flowers and pets.

Plan laboratory time for students to use reference materials, magnifiers, and other needed materials to classify 10 insects (order and family. Give genus and species of five of the insects.

Topics	*Understandings*	*Activities*
B. What are the divisions of the Plant Kingdom?	There are four major phyla of plants: Thallophytes, Bryophytes, Pteridophytes and Spermatophytes. The simplest phylum is the Thallophytes which includes the algae and fungi.	Using prepared transparencies or direct drawings illustrate the four basic divisions of the plant kingdom on the overhead projector pointing out the chief characteristics. Show differences in structure, reproductive process and other life functions.
1. Four major phyla	The fungi is a class of plants which contain no chlorophyll and are therefore dependent on other living things for food.	Divide the class into groups for research on the classes and their families
2. Distinctions	Families in the fungi class are bacteria, yeasts, molds, and mushrooms. Mosses and liverworts possess structures resembling simple stems and small leaves. Ferns make up a phylum which in ages past were the most important vegetation. Algae is a class of plants which vary from one-celled microscopic forms to rockweeds over a hundred feet in length and have great economic importance today.	Have groups present their findings along with illustrations, charts, models or specimen which will help clarify the information. Examine prepared slides of molds and bacteria of various types. See Ref. A. Grow some mold and watch its development. Examine under microscope. Find bases for classification. Have students gather specimen of local algae or fungi and examine in the lab with magnifiers. Make mushroom spore prints. See Ref. B.
C. Classification of plants	Seed plants represent the highest development in the plant kingdom and are divided into two classes: true flowering plants and conifers.	Introduce the idea of symbiotic relationships such as lichen. Discuss its value in creating soil. Show how plants play a part in the changing surface of the land in the development of animal communities. Set up a panel to gather ideas and present their findings on why plants are economically important. Specific reference should be made to the locale in which the students

Ref: (A) "How to Grow Bacteria and Prepare Slides," *The World of Living Things*
(B) *The World of Living Things*, Harcourt, Brace & World, p. 67, Mold growth p. 70.

Topics	*Understandings*	*Activities*
		reside and the existing problems of growth, conservation, and utilization of the important plants of the area.
D. Divisions of the Animal Kingdom	The animal kingdom is divided into the invertebrates and the vertebrates.	This topic can be effectively worked out on the basis of group inquiry. Assign groups to assemble the following: 1. Characteristics of group 2. Environment of group 3. Economic value of group 4. Representative animals
1. Major divisions	The main groups of invertebrates are: (1) one celled—Protozoa (2) simplest many celled—Porifera (3) cuplike animals—Coelenterata (4) spiny-skinned animals—Echinodermata (5) flat worms—Platyhelminthes (6) roundworms—Nemathelminthes (7) segmented worms—Annelida (8) soft-bodied animals—Mollusca (9) joint-foot animals—Arthropoda	
2. Invertebrate phyla	On the basis of the number of legs and other characteristics Arthropods are divided into four groups: (1) Myriapods, (2) Crustaceans, (3) Arachnids, (4) Insects. The insects make up the largest class within the animal kingdom.	This can be expanded to include posters, drawings, and other visual aids selected by the student.
3. Vertebrate classes	The Vertebrates are divided into five classes: (1) Fish (2) Amphibians (3) Reptiles (4) Birds (5) Mammals The Mammals are the highest form of animal life and they have the ability to dominate the earth.	During presentation, select a student to take notes on the board. These notes can be "edited" by the class and recorded by a group secretary. Ditto the finalized notes, so each student can have a copy of the group efforts. Several class periods can be used to assemble the material. Use the school library, as well as private sources.

Problem :How characteristics are related to classification.

Material: Set of paper figures: as follows (Number from 1 thru 16)

A. 1 red diamond—edges 3 inches long
1 red diamond — edges 1 1/3 inches long
1 yellow diamond—edges 3 inches long
1 yellow diamond — edges 1½ inches long
1 red circle—diameter 3 inches
1 red circle — diameter 1½ inches
1 yellow circle—3 inches diameter
1 yellow circle — 1½ inches diameter
1 red rectangle—1½ by 4 inches pinked edges
1 red rectangle 3/4 by 2 inches, pinked edges
1 yellow rectangle 1½ by 4 inches, pinked edges
1 yellow rectangle—3/4 by 2 inches pinked edges
1 red rectangle—1½ by 4 smooth edges
1 red rectangle—3/4 by 2 inches smooth edges
1 yellow rectangle—1½ by 4 inches smooth edges
1 yellow rectangle—3/4 by 2 inches smooth edges

B. Set of organisms:
ivy and philodendron
cricket and roach
housefly and honey bee
grasshopper and katydid
frog and toad
sowbug and pill bug
earthworm and centipede
salamander and lizard
black oak and white oak
sliver maple and sugar maple
butterfly and moth

Will be handed out in pairs... each pair is to be numbered... each organism is to be lettered

Activity: List numbers of figures

A. Write a description of each figure after its number. What four-characteristics are involved in each figure? If a figure were described to you without the number being given, could you pick it out?
What would be the easiest way to learn the characteristics and the quickest?
Arrange the figures into 3 groups by characteristics
Record how you divided the figures.
Arrange the figures into 2 groups by characteristics.
Record how you divided the figures.
Is there any other characteristic on which you could arrange the 16 figures into two groups?
Record how this can be done.
Re-arrange the figures into three groups as done previously.
What sub-groups do you find within each of the three groups?
Re-arrange the figures into the 2 groups done before and find the sub-groups.
How is this like the "set" theory in modern math?
Diagram your sets.
On the basis of what characteristic could the figures be said to all be in one group?

**Note to teacher:* at the conclusion of the work on the figures the "classification" may be worked out on the board as a summary for the work.

Problem: How characteristics are related to classification.

Materials: Listed on previous lab sheet under (B)

Activity: List the number of each group and under it the letters of the organisms in the pair

Write a list of ways the individuals in each pair are alike; then, make a list of the ways they are different.

On the basis of what characteristics would you arrange the organisms into two groups?

On the basis of what characteristics could they all be arranged in one group?

What are the main characteristics you considered in arranging the groups?

List the pairs you think could be grouped together and tell why.

Write a description of two individual organisms omitting their number and letter.

When the whole class is ready each group will read its classification description. Each student should write down what is described and check to see if he is right. Each student should be ready to justify his selection on the basis of characteristics.

*Note to the teacher: After the above work is complete, introduce the class to the divisions of biological classification such as kingdom, phylum and on through genus and species. Help the students draw parallels between these groups and their grouping of the paper figures. Then help them place the organisms into the proper classification. Point out that "arranging" into groups is classifying. Difficulties the students have in deciding how to place the organisms should be pointed out as similar to the trouble experienced by biologists in classifying plants and animals.

This material was adapted from "Laboratory and Field Studies in Biology" by Holt, Rinehart and Winston Inc. Pages 37-44.

Problem: Are all members of a species alike?

Materials: 100 leaves from the same tree

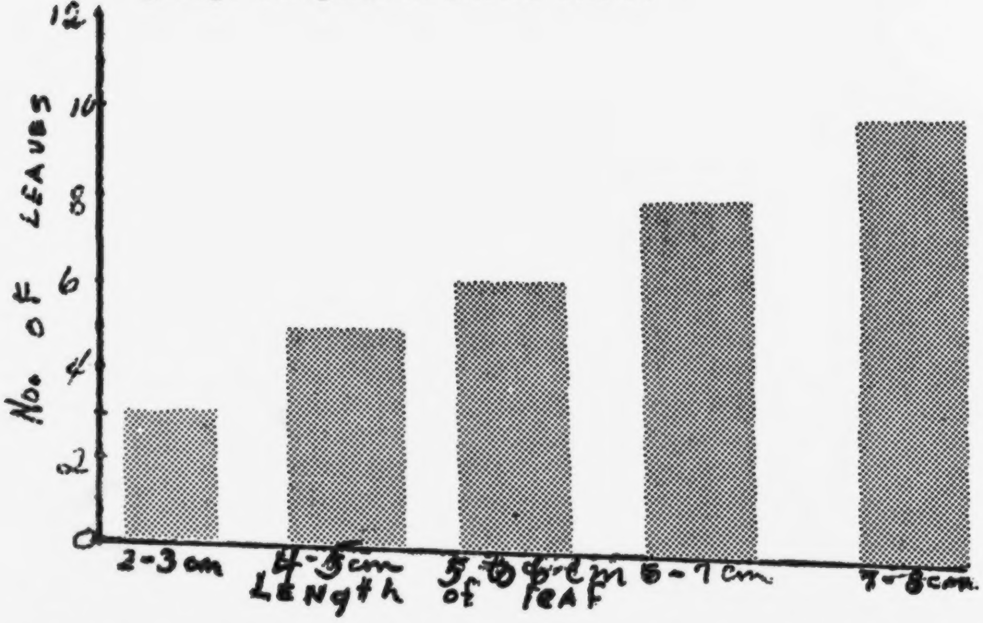
Information as to what part of the tree the leaves came from was taken.

Ruler, paper, pencil

Activity: Measure the leaves as accurately as possible using metric measures. Round all figures to nearest whole number.

Be careful to record the lengths along with the location from which the leaf came.

Make a histogram similar to the one shown below, using your measurements. First you determine the longest then the shortest. Divide the remaining distance between the extremes into regular intervals. Mark the position for the blocks that represent the length of leaves in various groups. Count the measurements that fall into each length-of-leaf group. Complete as shown below:



Conclusion: Does there appear to be a pattern for your histogram? Explain.

How does it compare to the patterns formed in other groups in your class?

Would you expect to find variations in the following traits?

a. weight of radish seeds
b. thorniness of honey locust trees
c. color of song sparrows
d. length of rabbit ears

One of the factors responsible for variations within a species is age. Both plants and animals show change as they grow older. Young birds are different in color from adults; a Siamese cat grows darker as it grows older. Can you suggest other factors that might also affect variations?

*Note to teacher: This lab lesson introduces the students to a new way of showing their findings or conclusion. This method can be used in other lab lessons.

Material in this lab lesson comes from "Laboratory and Field Studies in Biology" by Holt, Rinehart and Winston Inc. It has been adapted for class use.

Topics	*Understandings*	*Activities*
UNT IV—GENETICS		
A. Heredity and characteristics	Heredity is responsible for the characteristics of offsprings, both those in which likeness is shared and differences appear.	Review work studied earlier on Mendel and add any facts students obtain by further research.
	Hereditary changes take place slowly.	Develop an understanding of the basic mechanics of mitosis and meiosis.
B. Components of reproductive cells	The cell bears chromosomes or rod like bodies in the nucleus which carry pairs of genes, the determiners of hereditary characteristics.	Use diagrams and mimeographed notes to clarify study.
C. Cell division 1. mitosis 2. meiosis	Genes are complicated protein molecules. They may appear as dominant or recessive. Variations appear as a result of composite genes or as a result of mutations by radiation.	Define the terms necessary to the understanding of this topic. (hybrid, mutation, recessive, dominant, etc.) Use chart to show transmission of color blindness and hemophilia.
	Crosses between pure dominants and pure recessive produce hybrids.	Encourage reference work on other characteristics such as baldness, disease susceptibility, mentality, special aptitudes, etc. Discuss the advantages of hybridization and also the disadvantages.
		Consider hybrid corn and how it is produced.
		Work out simple crosses; first and second generations.
		Special reports and filmstrip on DNA.
		Prepare bulletin board of materials related to heredity which the students collect from

Topics	*Understandings*	*Activities*
		current magazines and papers. Show and discuss film on "Heredity." See No. 77. Use microprojector to study slides of cells undergoing mitosis. Diagrams used on overhead projector might be an alternative. Materials are also available for "viewers" on "Mitosis." from National Teaching Aids and booklets from the National Foundation. Show film: "Thread of Life", Bell Telephone Co. See film list, item No. 16.
UNIT V - HUMAN BIOLOGY A. Anatomy	The human body is composed of the following major systems: Skeletal Muscular Nervous Digestive Circulatory Respiratory Excretory Reproductive	The use of the "visible man" (plastic model) will help students gain an understanding of the various systems and their structural components and relationship. Prepare an exhibit of different animal bones. Refer to anatomy and physiology charts. Models of the various organs are also available and help students visualize the organ as a functional part of a system.
	The bony skeleton supports the body, protects its vital organs and makes different kinds of movement possible.	"Hemo, the Magnificent", "Gateway to the Mind," and "Thread of Life" should be used to implement factual concepts gained in discussion and research. See Bell Telephone listings of films.
	All movements of the body are brought about by the contraction of muscles controlled by the nerves.	Encyclopedia Britannica has a series of films on all the body systems which could be used if the above films are not available.

Topics	*Understandings*	*Activities*
	Nerve cells are the basic units of the nervous system, and their arrangement within the system makes different kinds of actions possible.	Many excellent films on anatomy and physiology are available from the Miss. State Health Department, Jackson - Ask for film bulletin.
	The endocrine system is closely related to the nervous system in control of human behavior and metabolism. Principal endocrine glands are pituitary, thyroid, adrenal, gonads, pancreas.	Mature bone materials and cartilage can be observed in chicken bones. Introduce terms: periosteum, ossify, etc.
		Use a bell jar apparatus to demonstrate the action of the lungs.
	Food materials are broken down in the digestive system and transported to the body by the blood stream.	Get heart or large vein and artery from butcher; compare strength and thickness.
	The blood is composed of plasma, red and white cells and various protein substances necessary for the blood to carry out its important functions.	Have students obtain information on blood types as well as the RH FACTOR.
B. Physiology	Oxygen is absorbed by the blood and carbon dioxide given off through capillaries.	Invite a medical technician to visit the class and show how the white count is made in the blood using the grid device; (scientific tool of the technician) or show them something of blood typing technique.
1. Basic Processes of selected systems	The kidneys are an important part of the excretory system. Their function is to remove salts, protein waste material, and excess water from the blood.	Introduce the term "enzyme" and help the students form an understanding of its place in body processes as a catalyst.
2. Enzymes	The reproductive systems provide sperm or egg cells and in the female, a place for development of the embryo until birth.	How do enzymes change the protein in gelatin? see reference a.

References:
(a.) *Basic Life Sciences,* Singer. p. 341.

Topics	*Understandings*	*Activities*
Physiology (continued)		
3. Vitamins		Discuss the regulatory aspects of vitamins. Have students trace the flow of blood through body and/or passage of a piece of buttered bread through the digestive system. Wall charts are helpful in showing details of some systems such as muscle-bone coordination, nerve connections with various body areas, structure of the heart, comparative sizes of blood vessels, etc.
4. Cancer		Obtain free materials from the National Foundation Cancer Society.
C. Metabolism	How do cells in the human body secure energy?	Point out the oxygen attached to the iron atom. Carbon dioxide will also attach to the iron atom. These facts help explain respiration in its fullest sense. Also point out that the chlorophyll molecule of a plant is identical with the hemoglobin except magnesium is the center instead of iron.
1. Energy for cells	Food is the fuel that provides energy for our bodies. We need energy to keep our bodies alive and warm, for work and play.	
2. Cell oxidation	When food is "burned" in our bodies by combining with oxygen, energy is released to our muscles and other body organs.	Review the information in "Hemo" concerning the lung function. Study plastic human models showing internal organs. Note the position of the lungs and discuss.
3. Calories	A calorie is the unit used to measure energy requirements of the body; it is also used to measure energy value of foods. Different foods of the same weight vary widely in the number of calories they provide.	Diagram the carbon dioxide-oxygen cycle and discuss its importance to man. Point out problems of the space programs concerning the carbon dioxide-oxygen cycle. Discuss the "algae solution" for space cabins. Challenge project: Set up nutrition experiment with rats.

Topics	*Understandings*	*Activities*
C. Metabolism (continued)	Young people need more calories than older people.	Conduct demonstration as to variation in heat content of different nuts. Burn the nut for fuel to heat a small volume of water. Point out that this is in essence a "calorie" measure.
	Most of our food is obtained from food substances called carbohydrates and from fats. The different classes of food are broken down chemically in different parts of the digestive system for use in living cells.	Help students work out their calorie requirements and set up a chart of calorie values of favorite foods of junior high students. Using individual mimeographed outline of human head and torso, show digestive organs, unlabeled. Discuss the process, using charts or overhead projector. Have students trace steps and label parts on their charts.
	The organs related to either a part of or the digestive system, include the mouth, esophagus, stomach, liver, pancreas, and intestines.	Assign special reports on the glands involved in digestion.
	The lungs furnish the oxygen necessary for the oxidation of food in the cells.	Exhibit anatomical chart to show the circulatory system. Trace the flow of blood from a cell through the entire system and back again.
	Oxygen is carried to the cells by the blood stream.	Have students do research to gain information about the components of blood.
	The respiratory system provides for passage of oxygen into the blood stream and for giving off of waste products of oxidation.	Write formula for the hemoglobin molecule on the board using different colored chalk for each element present. Compare formula for hemoglobin and chlorophyll.

Topics	*Understandings*	*Activities*
UNIT VI - CONQUEST OF DISEASE A. History of progress 1. Germ theory 2. Pasteur 3. Jenner 4. Koch 5. Lister 6. Fleming 7. Recent discoveries 8. Extension of life span	The concept of why and what of disease has changed with the advancement of science and technology. Many scientists have contributed to the development of medical science. Some diseases are still being investigated, and their causes and cures are still to be discovered. Through control and prevention of disease, man has extended his life span.	Using the "Health Hero Series" pamphlets, Metropolitan Life Insurance Co., have students conduct research on scientists contributing to progress of medical science. Define words such as immunize, innoculate, antiseptic, germicide, insecticide, serum and vaccine. Discuss epidemics of the past: how they were studied and eventually controlled. (Examples: yellow fever, polio) Let class propose control methods for epidemics. Discuss work being done locally to prevent spread of disease by insects. Show "Rival World". Discuss value of regular medical check ups, dental check ups and testing of eyes. Secure and show two or three films on communicable diseases from the Miss. State Board of Health. Innoculate a good apple with a needle which has been previously stuck in a rotten apple. Repeat the experiment sterilizing the needle in flame after having been stuck in rotten apple. Observe what happens to the apples and decide what is responsible for the results.

Topics	*Understandings*	*Activities*
B. Diseases of Man 1. Control, prevention a. Serums b. Vaccines c. Immunization		Invite a resource person such as local health officials or pathologist to talk to the group on immunization and related topics. Have a group of students conduct research in current publications and report on recent medical developments. Secure films from Heart Association. Grow bacteria in culture dishes innoculated by sneezing, touching with fingers, etc. Apply various germicides and note result. Innoculate some cultures with antiseptics before exposing to bacteria and note if bacteria develop as before. Bulletins may be obtained from the local health department. Students may refer to their own immunizations chart.
2. Community and personal health a. Sanitation	The problem of sewage disposal in home and in industry is closely connected to the problem of water supply.	Discuss the use of water in removing waste from the home. Note the value of the "trap" or curved pipe in drain outlets.
b. Water purification	Impurities in water may be: dissolved substances; suspended materials; living organisms. Large quantities of water are usually purified by a combination of methods. Among these are: sedimentation (settling); filtra-	Have students filter muddy water through columns of coarse sand held in place by cheese cloth. Suspend this device over a container and proceed. Note the results and discuss. Have students purify water with alum and

Topics	*Understandings*	*Suggested Activities*
Diseases of Man (continued)	tion (through rocks and sand), coagulation (addition of aluminum sulfate and lime), then sedimentation and filtration; aeration (spraying into the air); addition of chemicals (chlorine). Small quantities of water may be purified by distillation or by boiling. Distilled water is considered to be chemically pure. In an emergency, boiling serves to make water safe for drinking, because it kills disease germs.	limewater. (muddy water) Compare the two methods. Make a field trip to the local water plant and have a committee report to the class.
c. Water pollution	Water pollution occurs in areas with poor natural drainage and improper handling of sewage and industrial wastes.	Possibilities for research may include: (1) Local water pollution, industrial and non-industry related (2) Mississippi law (1964) concerning sewage disposal (3) Services of local health department (4) Problems of radioactive waste. Suggested projects are: (1) Obtain bottles (from State Board of Health) for water samples. Submit water samples to the State Board of Health for analysis. (2) Make a model of a city's water purification plant.
d. Public health departments	Organizations such as the Public Health Department carry out numerous programs to improve and maintain public health.	Use films obtained from local, state, or national health departments showing public health problems and methods of control.

Topics	*Understandings*	*Activities*
e. Harmful use of narcotics	The improper use of narcotics, tobacco, and alcohol bring about harmful effects on the human body.	Assign reports on various phases of the following topics: narcotics (example, laws concerning control of narcotics), tobacco, alcohol. Information related to smoking may be obtained from Division of School Health Service, Mississippi State Department of Education. Films on narcotics and alcohol are available from the Mississippi State Department of Education. Secure material from the American Cancer Society, the State T. B. Association, and Heart Association. Use wall charts presenting facts related to the topic, pictorially.
UNIT VII - AREAS OF HOBBIES AND VOCATIONS		
A. Birds	The student should develop an appreciation of his biological environment. The following areas are significant parts of his everyday experiences. Note: The teacher should use the material in this section all through the Life Sciences unit to extend learning. Those subjects which have not been sufficiently covered in other units may receive special emphasis in a separate unit.	Observe birds in their natural habitat with regard to call notes, song and other habits of birds. Obtain bird charts and bird cards, See reference (a) Obtain Mississippi Bird Check List cards (3 cents in quantity) from the State Wildlife Museum, Mississippi State Game and Fish Commission, Jackson, Mississippi. See Check List at end of unit. Also refer to "A Preliminary Check of the Vertebrates of Mississippi" and "General Information on Mississippi Bird Life," both by

References:
(a.) *Educators Guide to Free Science Materials*. Sixth annual edition-1965, Educators Progress Service, Randolph Wisconsin (published yearly).

Topics	*Understandings*	*Activities*
Birds (continued)		B. E. Gandy, State Wildlife Museum. See references in Bibliography. Learn characteristics of perching birds, water birds, shore birds, owls, hawks, scavengers, humming birds and other types.
		Locate bird sanctuaries and state parks in Mississippi. Where possible, conduct visits to those places, including Wildlife Museum of Game and Fish Commission in Jackson, Mississippi.
B. Fish	Game birds are protected by state and/or federal laws. Most other birds are protected by law. Students should become familiar with the laws concerning the birds of their vicinity.	Obtain from State Game and Fish Commission information concerning laws related to shooting birds (game or other). Secure bird stamps from National Wildlife Federation or bird cards from advertising sources.
	Recognition of birds by song or call notes is a rewarding experience.	Obtain bird recordings and become acquainted with bird calls and songs.
		One may write Cornell University, Ithica, New York, for bird discs, available for purchase.
		Obtain information from local game warden or State Game and Fish Commission on fishing laws.
	Laws regulating "fishing" are designed to insure continued fish populations and to encourage good sportsmanship.	Films on fish may be obtained from State Game and Fish Commission.
		Bulletins may be obtained from U. S. Bureau of Fisheries, Washington, D. C.
	Fish habits may be observed in an aquarium; for example, manner of locomotion, balancing, feeding, egg laying, etc.	Set up aquarium (where possible), using local fresh water fish.

Topics	*Understandings*	*Activities*
Fish (Continued)	A major public problem of the state and nation is the contamination of the streams, lakes, and coastal waters.	Observe locomotion - how fish propel themselves, "apply the brakes," and keep their equilibrium. Investigate all the environmental factors affecting fish which would account for "good" and "poor" fishing. Have students bring reports on the migratory habits of fish and how they have been interrupted by construction of dams in certain localities. (Examples: salmon) Investigate "Fish Kills" reported on some Mississippi rivers.
	The identification and knowledge of fish and their habits provide the fishermen with background information useful and enjoyable in this vocational pursuit. A greater appreciation of our natural resources may be developed.	Secure copy of "Mississippi Fish" by Miss Fannie Cook and report on species of fish commonly found in Mississippi fresh water. (Available at low cost from Mississippi State Wildlife Museum.)
	The Gulf Coast fishing industry, (including "shell fish") is a big business and very important to the economy of Mississippi.	Also refer to "A Preliminary Check List of Vertebrates", obtained from State Wildlife Museum. Secure pamphlets or book on Gulf Coast fisheries and associated industries. Write the Fish and Wildlife Commission at Pascagoula, Mississippi, requesting information. Write the Gulf Coast Research Lab, Ocean Springs, Mississippi, requesting copies of "Gulf Research Reports" and reprints on desired topics. (Be specific in request).

	Understandings	*Activities*
C. Insects	There are at least 8 major orders of insects. Each may be identified by special structural characteristics related to wing patterns, type of metamorphosis, mouth parts, chitinous covering and other features. While there are many useful insects, there are many destructive species taking a heavy annual toll of agricultural crops, household goods, stored materials, loss in farm animals, and in other ways. Insecticides assist in the control of insects, but many other types of control measures must be employed.	Make collections of insects, mount, identify, and label. Arrange according to orders. Materials on this work can be obtained from the local county agent or 4H representative. Secure information on *Insect Enemies of Southern Pines* from Mississippi Forestry Commission, Jackson, Mississippi. Contact the local termite exterminators for materials such as films, etc., on termite control. Obtain materials from the Hercules Powder Company, Hattiesburg. Mississippi, on insect identification. Other companies producing insecticides and the State Extension Service have similar material.
D. Trees	Trees may be identified by noting many different characteristics. Evergreen or deciduous Bark color and other characteristics Leaf characteristics Flowers and fruit characteristics Bud scales, size of twig, pith, etc. Cross section or longitudinal section of stem. Many trees may be identified by observing leaf types - simple or compound Veins - pinnate, palmate, netted, or parallel Margins - smooth, toothed, bristled, ser-	Take a field trip and identfy all trees in the vicinity of the school. Make a collection of leaves, observing color, simple or compound, leaf margin, venation. Separate chlorophyll from leaves by boiling in water and then in alcohol. Add glycerin to a portion of liquid in a test tube. Observe the separation of pigments. Collect different sections of wood and twigs. Identify: Wood, bark, leaves and fruit may be mounted together for tree identification. This is an excellent means of tree identification. Mount for displays.

Topics	*Understandings*	*Suggested Activities*
Trees (Continued)	rate, crenulate, lobed or entire Arrangement - opposite, alternate two-ranked or not two-ranked	The Alabama Dept. of Conservation, Division of Forestry, Montgomery, Ala. may supply a teaching guide "Developing Farm Woodlands in Alabama," or other materials may be available.
	Chlorophyll is the predominant leaf pigment, but other pigments are noticeable in early spring and late fall. These are Carotene, (yellow) Phycocyanin (blue), Xanthophyll (red)	Write the Mississippi Forestry Commission, Jackson, Miss. for booklets on forestry practices and other related information.
	Forestry is a major industry in Mississippi. The maintenance of the forests and forest industry depends upon a favorable balance between removal and growth of new trees. Proper forest practices are essential to maintain this balance.	Write Mississippi Extension Service, State College for information on forestry, such as bulletins, *Know Your Trees.* Investigate films and free materials on products obtained from wood, especially those produced in your own locality. Consult *Educators Guide for Free Science Materials* published by Educators Progress Service, Randolph, Wisconsin. See reference, a, Unit VII, page 173.
	In addition to lumber and other building materials the forests of Mississippi provide many other wood products such as paper, crates, and naval stores.	Remove portion of the lower epidermis of a leaf. Have students locate stomata throguh use of microscope.
	The forests are closely related to conservation of water, conservation of game and wildlife, parks and recreation, and soil conservation.	Postulate the function of stomata. Cover under surface of a leaf with paraffin and observe effect on a growing plant.
E. Flowering Shrubs F. Evergreens	Shrubs should be carefully selected to be adapted to soil, sun, and water conditions where they are to be placed and to provide flowers and berries through the year.	Visit a nursery to become acquainted with several varieties of flowering shrubs and evergreens.

Topics	*Understandings*	*Activities*
	Good gardening practices require attention and cultural practices of bulbs, shrubs, trees, and seed plants through most of the year. Aesthetic gardens involve landscaping and arrangements of planting as well as vigorous and colorful plants.	Identify the shrubs and evergreens used in landscaping your home or school. Note list of shrubs which attract birds at end of this unit. Secure "Landscape Gardening," bulletin, Mississippi State Extension Service, State College, Miss. Learn the proper care of shrubs by obtaining information from local "feed" and "seed" stores. Study the species of plants. Collect plants from different places representing different water requirements (hydrophytes, mesophytes, xerophytes). Observe adaptations to environment. Through a study of characteristics classify the specimen according to its water requirements. Locate lawn shrubs which appear "sick". Suggest reasons for sickness. Report to caretaker (wherever possible) and help with corrective measures.
G. Plant Culture	Soil is the storehouse of water and minerals, which it normally provides for the plant. Soil serves also as a "foothold" for the plant. The "diet" of plants may be regulated through hydroponics. The color and forms of flowers may be preserved by pressing and allowing to dry be-	Use plant hormones in the growing of plants. Compare with control sets. Suggested projects may include: (1) growing plants, using hydroponics. Compare with a control. (2) construction of a terrarium showing

Topics	*Understandings*	*Activities*
H. Wild Flowers	tween sheets of blotting paper. Normally plants are eaten by animals, but in some cases plants capture and digest animals. A nature-trail hike can be a delightful diversion from the artificial environment of the cities. Reacquaintance with trees, herbs, shrubs, rocks, streams, etc. is the delight of the naturalist.	one or more types of plant communities; (3) collecting, pressing, and mounting wild flower specimens common to the area. (4) a study of lawn grasses (Bermuda, St. Augustine, Zoysia, Carpet grass, others) from the viewpoint of: (1) suitability for lawn, golf course, shady areas (2) erosion control (3) susceptibility to insects (4) seasonal qualities. (5) research efforts toward unusual types of plants (venus fly trap, pitcher plant);
I. Lawn Grasses	Lawn grasses should be chosen for climates, soils, shades, and other environmental conditions. There are many types of grasses, some of value in agricultural crops, others especially useful in erosion control, some known largely as "weeds", some of little economic value, and a few especially suited for lawns.	(6) a hike on nature trail arboretum.

FIELD CHECK-LIST

317 species of living birds collected or photographed in Mississippi

OBSERVER ______
LOCALITY ______
DATE ______ REMARKS ______

Nomenclature and sequence—A.O.U. Check-list, 5th Edition
Families are separated by lines.

Symbols: 1. Breeding confirmed: Eggs or young collected or photographed.
2. Breeding noted: Nest and eggs or young seen, but not confirmed.
3. Largely confined to the coast.
4. Rarely found in the state, or distinctly local.

Loon, Common

Grebe, Horned
4 Grebe, Eared
1 Grebe, Pied-billed

Pelican, White
3 Pelican, Brown

3 Gannet

2 Cormorant, Double-crested

1 Anhinga
3 Frigatebird, Magnificent

1 Heron, Great Blue
1 Heron, Green
1 Heron, Little Blue
3 Egret, Cattle
3 Egret, Reddish
1 Egret, Common
2 Egret, Snowy
1 Heron, Louisiana
2 Heron, Black-crowned Night
1 Heron, Yellow-crowned Night
1 Heron, Yellow-crowned Night
1 Bittern, Least
Bittern, American

Ibs, Wood

4 Ibis, Glossy
4 Ibis, White-faced
2 Ibis, White

4 Swin, Whistling
Goose, Canada
4 Goose, White-fronted
Goose, Blue
Mallard
Duck, Black
1-3 Duck, Mottled
Gadwall
Pintail
Teal, Green-winged
Teal, Blue-winged
Widgeon, American
Shoveler
1 Duck, Wood
Redhead
Duck, Ring-necked
Canvasback
3-4 Scaup, Greater
Scaup, Lesser
Goldeneye, Common
Bufflehead
Oldsquaw
3-4 Eider, King
Duck, Ruddy
1 Merganser, Hooded
Merganser, Common
Merganser, Red-breasted
1 Vulture, Turkey
1 Vulture, Black

1 Waterthrush, Louisiana
1 Warbler, Kentucky
Warbler, Mourning
1 Yellowthroat
1 Chat, Yellow-breasted
1 Warbler, Hooded
Warbler, Wilson's
Warbler, Canada
Redstart, American

1 Sparrow, House

Bobolink
1 Meadowlark, Eastern
1 Meadowlark, Western
1 Blackbird, Red-winged
1 Oriole, Orchard
1 Oriole, Baltimore
Blackbird, Rusty
Blackbird, Brewer's
1-3 Grackle, Boat-tailed
1 Grackle, Common
1 Cowbird, Brown-headed

4 Tanager, Western
Tanager, Scarlet
1 Tanager, Summer

1 Cardinal
Grosbeak, Rose-breasted
4 Grosbeak, Black-headed
1 Grosbeak, Blue
1 Bunting, Indigo
1 Bunting, Painted
1 Dickcissel
4 Grosbeak, Evening
Finch, Purple
Siskin, Pine
Goldfinch, American
Towhee, Rufous-sided
Sparrow, Savannah
Sparrow, Grasshopper
Sparrow, LeConte's
Sparrow, Henslow's
3 Sparrow, Sharp-tailed
2-3 Sparrow, Seaside
Sparrow, Vesper
1 Sparrow, Lark
1 Sparrow, Bachman's
Junco, Slate-colored
4 Sparrow, Tree
1 Sparrow, Chipping
4 Sparrow, Clay-colored
1 Sparrow, Field
4 Sparrow, Harris'
Sparrow, White-crowned
Sparrow, White-throated
Sparrow, Fox
Sparrow, Lincoln's
Sparrow, Swamp
Sparrow, Song
Longspur, Lapland
4 Longspur, Smith's

HYPOTHETICAL LIST

6 species of birds recently seen in Mississippi
but not cinfirmed by collection

Loon- Red-throated
Spoonbill, Roseate
Goose, Snow
Scoter, Surf
Kittiwake, Black-legged
Warbler, Black-throated Gray

NOTES:

Prepared by the Records Committee
Mississippi Ornithological Society—1962
Order from M.O.S., 111 North Jefferson St.,
Jackson 2, Mississippi—3c per copy.

Kite, Swallow-tailed
1 Kite, Mississippi
Hawk, Sharp-shinned
1 Hawk, Cooper's
1 Hawk, Red-tailed
4 Hawk, Harlan's
1 Hawk, Red-shouldered
1 Hawk, Broad-winged
4 Hawk, Swainson's
4 Hawk, Harris'
Eagle, Golden
2 Eagle, Bald
Hawk, Marsh

2 Osprey

Falcon, Peregrine
Hawk, Pigeon
1 Hawk, Sparrow

1 Bobwhite

1 Turkey

1-4 Crane, Sandhill

1 Rail, King
1-3 Rail, Clapper
Rail, Virginia
Sora
4 Rail, Yellow
4 Rail, Black
1 Gallinule, Purple
1 Gallinule, Common
2 Coot, American

3-4 Oystercatcher, American

Plover, Semipalmated
3 Plover, Piping
2-3 Plover, Snowy
1-3 Plover, Wilson's
1 Killdeer
Plover, American Golden
Plover, Black-bellied

3 Turnstone, Ruddy

1 Woodcock, American
Snipe, Common
4 Curlew, Long-billed
3 Whimbrel

Plover, Upland
Sandpiper, Spotted
Sandpiper, Solitary
2-3 Willet
Yellowlegs, Greater
Yellowlegs, Lesser
3 Knot
Sandpiper, Pectoral
Sandpiper, White-rumped
4 Sandpiper Baird's
Sandpiper, Least
3 Dunlin
Dowitcher, Short-billed
Dowitcher, Long-billed
Sandpiper, Stilt
Sandpiper, Semipalmeted
Sandpiper, Western
Sandpiper, Buff-breasted
3 Godwit, Marbled
3 Sanderling

Avocet, American
3 Stilt, Black-necked
4 Phalarope, Wilson's

3 Jaeger, Parasitic

4 Gull, Glaucous
Gull, Herring
Gull, Ring-billed
1-3 Gull, Laughing
4 Gull, Franklin's
Gull, Bonaparte's
1-3 Tern, Gull-billed
Tern, Forster's
1 Tern, Common
3-4 Tern, Sooty
1 Tern, Least
1-3 Tern, Royal
1-3 Tern, Sandwich
3 Tern, Caspian
Tern, Black
3-4 Tern, Noddy

1-3 Skimmer, Black

1 Dove, Rock
4 Dove, White-winged

1 Dove, Mourning
Dove, Ground

1 Cuckoo, Yellow-billed
Cuckoo, Black-billed
4 Ani, Groove-billed

1 Owl, Barn

1 Owl, Screech
1 Owl, Great Horned
4 Owl, Burrowing
1 Owl, Barred
Owl, Long-eared
Owl, Short-eared

1 Chuck-will's-widow
Whip-poor-will
1 Nighthawk, Common

1 Swift, Chimney

1 Hummingbird, Ruby-throated

1 Kingfisher, Belted

1 Flicker, Yellow-shafted
1 Woodpecker, Pileated
1 Woodpecker, Red-bellied
1 Woodpecker, Red-headed
Sapsucker, Yellow-bellied
1 Woodpecker, Hairy
1 Woodpecker, Downy
1 Woodpecker, Red-cockaded
4 Woodpecker, Ivory-billed

1 Kingbird, Eastern
3-4 Kingbird, Gray
Kingbird, Western
4 Flycatcher, Scissor-tailed
1 Flycatcher, Great Crested
1 Phoebe, Eastern
4 Phoebe, Say's
Flycatcher, Yellow-bellied
1 Flycatcher, Acadian
Flycatcher, Traill's
Flycatcher, Least

1 Pewee, Eastern Wood
4 Pewee, Western Wood
4 Flycatcher, Olive-sided
4 Flycatcher, Vermilion

1 Lark, Horned

Swallow, Tree
Swallow, Bank
1 Swallow, Rough-winged
1 Swallow, Barn
2 Swallow, Cliff
1 Martin, Purple

1 Jay, Blue
1 Crow, Common
2 Crow, Fish

1 Chickadee, Carolina
1 Titmouse, Tufted

2 Nuthatch, White-breasted
Nuthatch, Red-breasted
1 Nuthatch, Brown-headed

Creeper, Brown

Wren, House
Wren, Winter
1 Wren, Bewick's
1 Wren, Carolina
1-3 Wren, Long-billed Marsh
Wren, Short-billed Marsh

1 Mockingbird
1 Catbird
1 Thrasher, Brown

1 Robin
1 Thrush, Wood
Thrush, Hermit
Thrush, Swainson's
Thrush, Gray-cheeked
Veery
1 Bluebird, Eastern

1 Gnatcatcher, Blue-gray
Kinglet, Golden-crowned
Kinglet, Ruby-crowned

Pipit, Water

	Pipit, Sprague's
	Waxwing, Cedar
1	Shrike, Loggerhead
1	Starling
1	Vireo, White-eyed
4	Vireo, Bell's
	Vireo, Yellow-throated
	Vireo, Solitary
1	Vireo, Red-eyed
	Vireo, Philadelphia
1	Vireo, Warbling
1	Warbler, Black & White
1	Warbler, Prothonotary
1	Warbler, Swainson's
	Warbler, Worm-eating
	Warbler, Golden-winged
	Warbler, Blue-winged
4	Warbler, Bachman's
	Warbler, Tennessee
	Warbler, Orange-crowned
	Warbler, Nashville
1	Warbler, Parula
	Warbler, Yellow
	Warbler, Magnolia
	Warbler, Cape May
	Warbler, Black-throated Blue
	Warbler, Myrtle
	Warbler, Townsend's
	Warbler, Black-throated Green
	Warbler, Cerulean
	Warbler, Blackburnian
2	Warbler, Yellow-throated
	Warbler, Bay-breasted
	Warbler, Blackpoll
1	Warbler, Pine
1	Warbler, Prairie
	Warbler, Palm
2	Ovenbird
	Waterthrush, Northern

NATIVE PLANT PROTECTION LIST FOR MISSISSIPPI

Below is a list of native plant material found in decreasing amounts in the State of Mississippi, and in order to protect them from extinction, it is recommended that they be placed on a conservation list and not be permitted to be shown in any standard flower show.

1. *RARE SPECIES*

Flowers and seed pods of these plants should not be removed. Plants should not be disturbed unless site is to be destroyed. Such site should be considered a wildflower preserve and protected as such.

Pink Dogwood*
Yellow Violet
Indian Pipe*
Lady Slipper*
Closed Gentians
Gingseng

2. *NOT COMMON*

Not found in quantity throughout the state, but in relative abundance in limited areas. Roots should not be disturbed and enough flowers left to go to seed. Site should be considered wildflower preserve.

Cowcumber
Flowering Dogwood**
American Holly
Cardinal Flower
Hepatica
Puccoon (Yelow phlox)
Wild Columbine
Wild Iris
Yellow and white fringed orchids
Redbud
Tulip Poplar
Bloodroot
Gayfeather
Indian Pink
Trillium
Wild Larkspur
Wild Ferns

3. *COMMON*

Common in certain areas, such as longleaf pinelands, loessal bluffs.

Blue stars (blue dogbane)
Bittersweet
Cornflower
Crabapple
Lupine
Oak leaf hydrangea
Poppy mallow
Rose gentians
Swamp iris
Wild phlox (Sweet William)
Wild verbena
Yellow jasmine
Blue lobelia
Bird's foot violet (Johnny-Jump-Up)
Coral bean
Jack-in-the-pulpit
Mandrake (common May apple)
Pitcher plant
Red haw tree
Silver bells
Viburnum (maple leaf)
Wild azalea (bush honeysucle)
Yellow false foxglove
Yucca
False dragonhead

4. *ABUNDANT*

Found in most regions in quantities. Most absent from Delta. Many classed as common or abundant are not in danger of extinction, but they should not be subject to wanton destruction for seasonal decoration, mass transplanting, or invasion by exotic plants used in soil erosion projects. (Kudzu)

Ground nut vine
Huckleberry
Wild geranium
Milkweed
Smilax (trailing ground cover)
Red or native cedar

5. *VERY ABUNDANT*

The following plants are not in need of protection at this time:

Asters
Coreopsis
Evening primrose
Morning Glory
Mustard
Queen Anne's Lace
Sunflower
Vetch
Blackeyed Susans
Dandelion
Goldenrod
Mullein
Pokeberry
Sweet Clover
Trumpet creeper
Wild lettuce

*Very Rare

**In danger of being completely destroyed.

Acknowledgement is made to Dr. James D. Ray, Botany Department, Mississippi State University, and Mrs. Louise Gray of Greenville, who helped compile this list for MISS GARDNER, official publication of the Garden Clubs of Mississippi, Inc., from which this information was derived.

BERRIED SHRUBS THAT WILL ATTRACT BIRDS TO YOUR GARDEN

RED CEDAR (Juniperus virginia) attracts Bluebird, Cardinal, Chipping Sparrow, Mockingbird, Robin

DOGWOOD (Cornus florida) attracts Brown Thrasher, Purple Finch, Robin, Towhee, Vireos

HOLLY (Ilex opaca and others) attract Flicker, Robin, Thrushes

BARBERRY (Berberis thunbergi) attracts Catbird, Chipping Sparrow, Thrushes, Junco, Song Sparrow

BEAUTYBERRY (Callicarpa Purpurea) attracts Robin, Catbird, Towhee, Brown Thrasher, Bluebird, Mockingbird.

BLUEBERRY (Vaccinium spp.) attracts Bluebird, Brown Thrasher, Catbird, Thrush, Mockingbird, Towhee

HONEYSUCKLE VINE (Lonicera halliana) attracts Bluebird, Waxwing, Chipping Sparrow, Goldfinch, Purple Finch, Song Sparrow

EUONYMUS (Euonymus spp.) attracts Cardinal, Finches, Towhee, Brown Thrasher, Catbird.

PYRACANTHA (Pyracantha spp.) attracts Cardinal, Robin, Catbird, Mockingbird

SUMAC (Rhus candensis) attracts Bluebird, Finches, Robin

VIBURNUMS (Virburnum spp.) attracts Bluebird, Waxwing, Flicker, Finches, Robin, Thrushes.

VIRGINIA CREEPER (Parthenocissus) attracts Flicker, Mockingbird, Purple Finch, Robin and many others.

****

To attract Seedeaters of the bird population plant:

PRINCESFEATHER (Amaranthus hypochondriacus)

LOVE-LIES-BLEEDING (A. candatus)

ASTERS, ROCKPURSLANES, BLESSED THISTLE, CENTAUREAS, CALIFORNIA POPPIES, COSMOS, MARIGOLD, SUNFLOWERS, TARWEED, FORGET-ME-NOTS, PRINCESPLUME, SAGALINE, PORTULACA, SILENE, ZINNIA.

Also: MILLET, BARNYARD GRASS, FOXTAIL, CANARY GRASS.

For Game Birds: ALFALFA, BEGGARWEED, BUCKWHEAT, CLOVER, CORN, COWPEA, FLAX, HEMP, SUDAN GRASS, WHEAT, and SOYBEAN

TREES: Alder, Birch, Ash, Boxelder, Elm, Pines

****

To attract the Fruit-eaters, plant the following: JUNIPER, HACKBERRY, BAYBERRY, THORN APPLE, FLOWERING APPLE, MOUNTAIN ASH, HOLLY, VIRGINIA CREEPER, SOUR GUM, PERSIMMON, SNOWBERRY, BUSH HONEYSUCKLE

For Hummingbirds, plant any of the following: ABELIA, ALTHEA, MIMOSA, AZALEAS, BEAUTYBUSH, BUDDLEIA, HONEYSUCKLE, TRUMPET VINE, WEIGELIA

HONEYSUCKLE (Lonicera spp.) attracts Catbird, Brown Thrasher, Mockingbird, Robin, Towhee.

NINTH GRADE

INTRODUCTION TO PHYSICS AND CHEMISTRY

Topics	*Understandings*	*Suggested Activities*
I. Introduction Physical Science and Its Areas A. Unification of Physical Science B. Basic Assumptions in Scientific Pursuits	It should be noted that basic phenomena and their underlying principles are separated because of expediency. Atoms no longer belong solely to the study of chemistry, but must appear also in any study of physics. Such overlapping of subject matter results in the unification of the physical sciences.	Discuss radioactive materials and their relationship and use in all fields of science. (See reference a.)
	The following are some of the basic or fundamental assumptions in scientific pursuits: There is a general lawfulness or orderliness in nature. "Laws" of nature can be discovered and explained. The degree of understanding of natural phenomena is proportional to the matematical treatment involved. There is a simplicity and symmetry in nature.	Consult unit of metric measure in 7th, 8th, and 9th mathematics texts. A wall chart of the metric system should be displayed. Pupil activity: Using a quart fruit juice can and other shaped containers, calculate volume, using the metric system.
II. Relationship of Mathematics to Physics and Chemistry A. Comparison of English and Metric Systems	Students must understand the importance of mathematics in solving science problems. The metric system is being adopted throughout the world and is the universal scientific system in calculations.	Check the results with a graduated cylinder. Volumes of solids may be calculated and the results compared to the displaced volume, using the over-flow can.

References:

(a.) *General Science Handbook.* Bureau of Curriculum Development. New York State Education Department, Albany, New York. 1956 edition.

Study of prefixes should be included. The metric system is a very logical structure and, therefore, easy to learn. The names of the metric units consist of the name of the basic unit (meter, gram, liter, and similarly; ampere, volt, ohm, cycle, etc.) and a prefix which is nothing but a *factor* telling how much larger or smaller the derived unit is than the basic unit.

Student Activity:
Problem solving using the metric system.
Math: $\pi r^2 = A$
Titration formula: $V_1N_1 = V_2N_2$
From Newton's Laws:
$F = ma$ and $D = rt$
(F = force, m = mass, a = acceleration, D = distance, r = speed, t = time)
Also $S = \frac{1}{2}gt^2$
(S = distance, t = time, g = acceleration of gravity)

The metric system is easy to use and has many advantages over the English.

WHAT IS THE METRIC SYSTEM?

The metric system is generally used in the science laboratory and is the common system of most of the nations of the world.

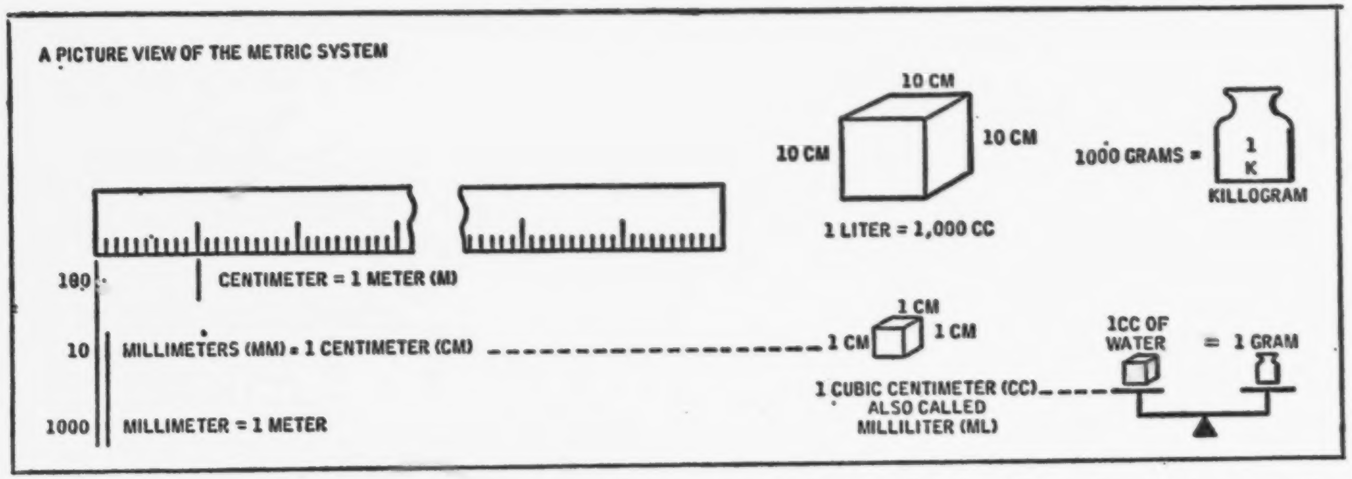
In the metric system all units go by tens. Once learned it is much simpler than our complex English system of measurements—as you shall see.

LENGTH	VOLUME	WEIGHT
1,000 meters = 1 KILOmeter	1,000 cc = 1 liter	1,000 grams = KILOgram
THE METER is the base length. (It is about 39.4 inches long)	The cubic centimeter (cc) is the base volume.	

1/100th of meter = CENTImeter. . . . . 1 cc of water = the base weight unit.

1 gram, 1/1,000th of meter = MILLImeter

1/100th gram = MILLIgram


A PICTURE VIEW OF THE METRIC SYSTEM
100
CENTIMETER = 1 METER (M)
10
MILLIMETERS (MM) = 1 CENTIMETER (CM)
1000
MILLIMETER = 1 METER
10 CM
10 CM
10 CM
1 LITER = 1,000 CC
1 CM
1 CM
1 CM
1 CUBIC CENTIMETER (CC)
ALSO CALLED
MILLILITER (ML)
1000 GRAMS =
1
K
KILLOGRAM
1CC OF
WATER
= 1 GRAM

CONVERSION TABLES Usually you will work entirely within either the Metric or the English systems of measure. However, occasionally you may find it necessary to change from one to the other, the following tables will help you do this.

1 in. = 2.54 cm
1 mile = 1609.4 m.
1 lb. = 453.6 gm.
1 oz. = 28.35 gm.
1 ft. = 30.5 cm.
1 cu. in. = 16.4 c. c.

1 m. = 39.37 in.
1 cm. = .39 in.
1 kgm. = 2.2 lb.
1 liter = 61.03 cu. in.
1 liter = 1.06 qts.
1 quart = .95 liters

TO ILLUSTRATE THE SIMPLICITY OF THE METRIC SYSTEM—DO THESE PROBLEMS:

METRIC SYSTEM:
How many meters and centimeters are *1653 centimeters?*

ENGLISH SYSTEM:
How many yards and inches are *1563 inches?*

METRIC SYSTEM:
How many grams are there in *1.3 Kilograms?*

ENGLISH SYSTEM:
How many ounces are there in *1.3 pounds?*

Which system was the easier to work with in the above examples? Did you notice that by moving the decimal point changes are easily made in the metric system?

This is because all units are in relationship by tens.

SUGGESTION: Compare the metric system to U. S. currency. The dollar and the cent become the DOLLAR and CENTI - DOLLAR. The decimal relationships are easily seen in this comparison.

EXAMPLE:
10 mills = 1 cent
10 cents = 1 dime
10 dimes = 1 dollar
10 millimeters = 1 centimeter
10 cm = 1 dm
10 dm = 1 meter

Topics *Understandings*

Responsibility for the presentation and promotion of the metric system is centered at the International Bureau of Weights and Measures, at Sevres, France, which was established under the Treaty of the Meter of 1875. The United States is an adherent to the Treaty of the Meter.[1]

MOST COMMON USES OF PREFIXES

		LENGTH
1 000 millimeters	mm	= 1 METER (about 40 inches) m
100 centimeters	cm	
10 decimeters	dm	
1 000 meters	m	= 1 kilometer (about 5/8 mile) km
		MASS
1 000 000 micrograms	ug	= 1 GRAM (about 15 grains) g
1 000 milligrams	mg	
1 000 grams	g	= 1 kilogram (about 2 pounds) kg
		CAPACITY
1 000 milliliters	ml	= 1 LITER (about 1 quart) l
1 000 liters	l	= 1 kiloliter kl

TOPICS FOR STUDY (Necessary in order to acquire skill in using the metric system.):

Conversion of metric units to other metric units.
Conversion of metric measures to English system measures and vice versa.
Conversion of metric units to powers of 10.
Mathematical processes in combining numbers as powers of 10.
Conversion of metric units by the Unit Factor Method.
Writing numbers in scientific notation.

In the metric system, how much would a liter of water weigh? (Do not count the container.)

To give you practice in weighing small things, weigh a nickel to the nearest tenth of a gram.

There are some obvious advantages to the use of the metric system. Can you name three of them?

Suggested Activities

Experiment 1: "Using the Metric System" Examine a meter stick. This length is basic to measurements of length, volume, and weight in the metric system. The meter stick is 3.37 in. longer than a yard stick in the English system of measurement. Notice that the *meter* stick is divided into 100 parts, each part called a *centimeter* and that each centimeter is divided into ten parts called *millimeters.*

a. Using your meter stick, measure the edges of this page in centimeters and tenths of a centimeter.

Long edge____________

Width ____________

b. In like manner, measure the height of your study table.

Height____________

a. Weigh a dry beaker (100 ml)

b. Measure 50 milliliters (cc) of water in a measuring cylinder. Read the low point of the curved surface (meniscus).

c. Pour the water into the beaker and weigh.

d. Subtract the weight of the dry beaker to determine the weight of 50 ml of water.

(c) beaker and water = ______grams
(a) dry beaker = ______grams
(d) c − a = ______grams (weight of 50 ml water.)

(e) What is the weight of one ml of this water?

(f) What basic relationship between weight and volume does your experiment show?

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[1] Metric System, Chart, U. S. Department of Commerce, National Bureau of Standards, Miscellaneous publication, 232, Revised April 1, 1963. Price 50 cents.

	WHOLE NUMBERS and PARTS by 10:		FACTORS:			ETYMOLOGY:
	Fractional Parts: (Submultiples)	Decimal Equivalents: (Submultiples)	Numerical— Powers of 10:#	Word— Prefixes:	Symbols*	
MULTIPLES	1 000 000 000 000.0		10^{12}	tera	T	Greek, "teras" = monster
	1 000 000 000.0		10^{9}	giga	G	Greek, "gigas" = giant
	1 000 000.0		10^{6}	[mega]	M	Greek, "megas" = great
	1 000.0		10^{3}	kilo	k	Greek, "chilioi" = 1000
	100.0		10^{2}	hecto	h	Greek, "hekaton" = 100
	10.0		10^{1}	deka	da	Greek, "deka" = 10
	1.0		10^{0}	UNIT		Latin, "unus" = one, 1
SUBMULTIPLES	$\frac{1}{10}$	= 0.1	10^{-1}	deci	d	Latin; "decimus" = tenth
	$\frac{1}{100}$	= 0.01	10^{-2}	centi	c	Latin, "centum" = 1/100
	$\frac{1}{1\ 000}$	= 0.001	10^{-3}	milli	m	Latin, "mille" = 1/1000
	$\frac{1}{1\ 000\ 000}$	= 0.000 001	10^{-6}	[micro]	μ**	Greek, "mikros" = small
	$\frac{1}{1\ 000\ 000\ 000}$	= 0.000 000 001	10^{-9}	nano	n	Greek, nanos = dwarf
	$\frac{1}{1\ 000\ 000\ 000\ 000}$	= 0.000 000 000 001	10^{-12}	pico	p	Italian, pico = tiny
			10^{-15}	femto	f	(Note: Popular prefixes are those between brackets.)
			10^{-18}	atto	a	

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* The symbols listed are as agreed on by the International Committee on Weights and Measures, 1962. Symbols have numerical as well as word meaning.

# Positive powers indicate the number of zeros to the left of the decimal place, that is, in whole number places. Negative powers indicate the number of decimal places, including the integers.

** This is the symbol for the Greek letter Mu. It is also the symbol for 1 millionth of a meter, which is called a micron.

A metric unit of measure for light wavelengths is the Angstrom (10^{-10} meters). The symbol is Å.
Consider the position of the powers as numbers in relation to the line concept.

Topics	*Understandings*	*Suggested Activities*
B. Basic and Derived Units	Basic units of any system are the units of distance, mass, and time. (All other units are derived from these or combinations of these.)	Student Activity: Classify the units used to measure the following as to basic or derived: distance, rate, velocity, work, power, volume, area, and acceleration.
C. Scientific Notation Significant figures and approximations		
1. Scientific notation	Very small or very large numbers can be expressed in powers of 100. Powers of 10 are very useful in understanding the functions of the slide rule and logarithmic computations.	Distance to the sun can be shown as 93,000,000 miles from the earth or as 9.3×10^7. (Use other similar problems.) Student Activity: Calculate the time for light to travel from the sun to the earth. Velocity — 1.86×10^5 mi/sec $T = D/V$ = time D = distance V = velocity $T = \frac{9.3 \times 10^7}{1.86 \times 10^5}$ sec. $5 \times 10^2 = 500$ sec. Other Examples of scientific notation $.064 = 6.4 \times 10^{-2}$ $.00672 = 6.72 \times 10^{-3}$
	Proper scientific notation involves one number to the left of the decimal point. Any basic physics or algebra text would be adequate to illustrate this.	

Topics	*Understandings*	*Suggested Activities*
2. Significant figures and approximations	Measurements are approximate, depending on the instrument and the person measuring. Where precision is desired the precision instruments are used.	Take any rectangular solid and make the 3 measurements as accurately as possible, retaining all figures. Multiply to find the volume. Then approximate measurements using only significant figures. Compare.
D. Conversion of Units	Accuracy and speed of calculation may be increased by using the unit factor method.	Problem solving using this method can be found in *Modern Physics* (4).

Activities:

How many cm is one light year? Since light travels 186,000 mi/sec.

$$\frac{\text{cm}}{\text{year}} = 186{,}000\ \frac{\text{mi}}{\text{sec}} \times \frac{5280\ \text{ft}}{1\ \text{mi.}} \times \frac{12\ \text{in.}}{1\ \text{ft.}} \times \frac{2.54\ \text{cm}}{1\ \text{in.}} \times \frac{3600\ \text{sec}}{1\ \text{hr.}} \times \frac{24\ \text{hr.}}{1\ \text{day}}$$

$$\times \frac{365\ \text{days}}{1\ \text{year}} = (1.86 \times 10^5)\ (5.28 \times 10^3)\ (1.2 \times 10^1)\ (2.54)\ (3.6 \times 10^3)$$

$$\times (2.4 \times 10^1)\ (3.65 \times 10^2)\ \frac{\text{cm}}{\text{year}}$$

How many cubic millimeters are contained in one cubic yard?

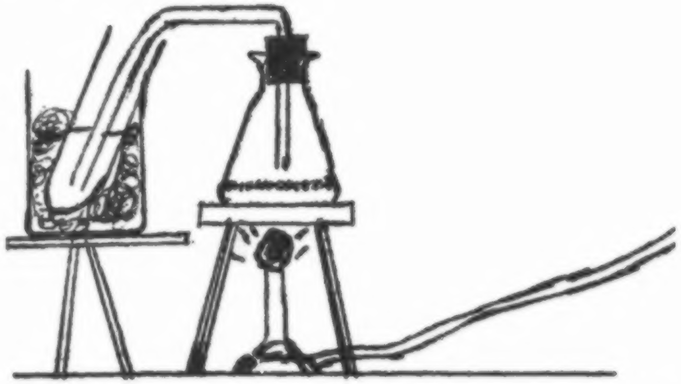
$$\underline{\hspace{3em}}(\text{mm})^3 = \left(1\ \text{yard} \times \frac{3\ \text{ft.}}{1\ \text{yd.}} \times \frac{12\ \text{in.}}{1\ \text{ft.}} \times \frac{2.54\ \text{cm}}{1\ \text{in.}} \times \frac{10\text{mm}}{1\ \text{cm}}\right)^3$$

$$= (3)\ (12)\ (2.54)\ (10)\ \text{mm}^3$$

What is a snail's pace in miles per hour? Assume that a snail travels 0.5 cm/sec.

$$\underline{\hspace{3em}}\frac{\text{mi}}{\text{hr.}} = \frac{0.5\ \text{cm}}{1\ \text{sec.}} \times \frac{1\ \text{in.}}{2.54\ \text{cm}} \times \frac{1\ \text{ft.}}{12\ \text{in.}}\ \frac{1\ \text{mi.}}{5280\ \text{ft.}} \times \frac{60\ \text{sec.}}{1\ \text{min.}} \times \frac{60\ \text{min.}}{1\ \text{hr.}}$$

$$= \frac{(5 \times 10^{-1})\ (6.0 \times 10^1)\ (6.0 \times 10^1)}{(2.54)\ (1.2 \times 10^1)\ (5.28 \times 10^3)}\ \frac{\text{mi}}{\text{hr}}$$

Topics	*Understandings*	*Suggested Activities*
E. Use of slide rule	In 9th grade science the mechanics of multiplication, division, the extraction of roots, and powers of numbers can be readily determined by the use of a slide rule.	The use and mechanics of the slide rule can be learned from the handbooks which accompany all slide rules. Frequent use of the slide rule is desirable.
III. Organization of Matter A. Identification of Properties	All matter is identified by two basic properties, i.e., mass and volume. Specific matter is identified by specific properties which are either physical or chemical.	Identify specific solids, liquids, and gases that can be seen in or out of the classroom. Show changes, both physical and chemical, by demonstrations.
B. States of Matter 1. Kinetic molecular theory	Physical properties are those such as hardness and density. Chemical properties are those such as the ability of iron (Fe), to combine with O_2 to form iron rust (F_2O_3), etc.	Experiment 2: "States of Matter" Materials: test tube, beaker, burner, salt, ice, and thermometer.  Purpose: To observe the change of state of matter. Procedure: Distill about 1½ inches of water into a test tube—stir this tube containing the distilled water in the beaker containing salty crushed ice. Observe temperature change during the stage of heat of vaporization and heat of fusion; discuss boiling points.

Topics	*Understandings*	*Activities*
		Pour finger nail polish remover (acetone) over dry ice, and place several objects such as a wiener, or rubber band, or other available materials to show the rapid freezing of objects. Then shatter.
2. Solids, liquids, gases, and plasma.	General characteristics, such as weight, volume, and definite shape in each state vary.	
	Mass inertia-definitions and relationships should be noted.	"Inertia" (Film from Modern Teaching Aids) See film list, item 3.
C. Classification of Matter 1. Heterogenous mixtures and alloys	This topic should be used to acquaint the pupil with the behavior of materials.	Show examples of the 3 states dispersed in each other. There are many illustrations present in nature, such as, muddy water, clouds, and whole milk.
Experiment 3: "Heterogenous Mixtures"	All alloys are mixtures, but all mixtures are not alloys. Suspensions, emulsions, and dispersions are also mixtures.	Some examples and illustrations may be found to represent each. Example: The alloy, brass is a mixture, but the mixture, sand and salt, is not an alloy.
Prepare a mixture of iron filings, salt, and white sand and present to the student the problem of how the materials may be separated. Make available to the student an array of equipment, such as beakers, magnets, burners, etc.	A solution has identifying characteristics: it is non-filterable; dissolved particles do not settle out; dissolved particles are not visible, even with the aid of a microscope.	Make several solutions and compare with other mixtures which are not solutions.
	Examples: tea, sweetened water	
2. Homogenous a. Solutions	Elements and compounds can be identified by their physical and chemical properties.	

DISTILLATION

Experiment 4:

INTRODUCTION

Chemically pure water is often a requirement in chemical reactions. To prepare chemically pure water it is necessary to evaporate the water and condense the resulting vapors. This process is distillation. Distillation is used in the preparation of petroleum products, acids, alcohols, and many other products. There are some liquids which cannot be distilled.

PURPOSE

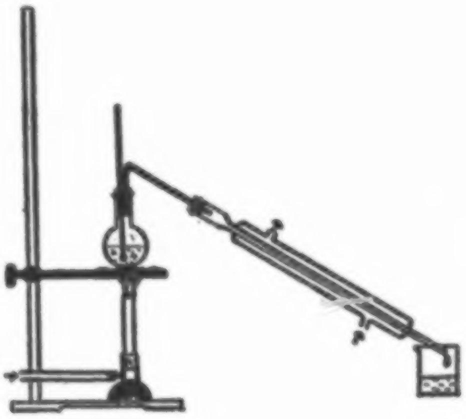
To prepare chemically pure water by distillation.

MATERIALS

500 ml florence flask, Liebig condenser or about 4 ft of 6mm glass tubing, ring stand, ring, wire gauze, bunsen burner, one-hole stopper, small beaker, copper sulfate solution, ammonia water, white vinegar or acetic acid, litmus paper.

PROCEDURE

1. The class will be divided into three sections.
2. *Group A* will prepare their solution by dissolving 5 grams of copper sulfate in 250 ml of distilled water. Note the color.
3. *Group B* will prepare their solution by diluting 10 ml of acetic acid with 240 ml of distilled water. Note the effect of the solution on litmus paper. White vinegar may be used for the acetic acid.
4. *Group C* will prepare their solution by diluting 5 ml of ammonia water with 240 ml of distilled water. Note the odor of the ammonia gas as it escapes from the solution and the effect of the solution on litmus.



5. Set up the apparatus as shown in the illustration.
6. Heat the solution until it begins to boil. Keep it boiling slowly.
7. Collect the distillate in test tubes. Collect for a period of *two minutes* in each test tube, remove, and replace with a clean test tube.

8. Continue replacing test tubes every *two* minutes until you have boiled the water for *twenty* minutes.

9. Check the distillate.

   a. Group A—Use a watch glass over a beaker 1/3 full of boiling water. Evaporate a few drops of the first distillate to dryness.

   b. Group B—Check the distillates for odor and with litmus paper.

   c. Group C—Check the distillates with litmus paper.

OBSERVATIONS

Group A

1. What was the color of the original solution?
2. Was a color observed in the first distillate collected?
3. Did a solid residue remain after evaporation of the first distillate?
4. How chemically pure was the water collected?

Group B

1. Describe the odor of the original solution.
2. How did the original solution affect litmus paper?
3. Which test tube of distillate, if any, did not affect litmus paper? Explain.
4. How chemically pure was the water collected (distillate)?

Group C

1. How did your original solution affect litmus?
2. Which test tube of distillate, if any, did not affect litmus paper? Explain.
3. How chemically pure was the water collected?

FURTHER RESEARCH

1. Activated charcoal is used to remove odors from city water supplies. Would boiling water in an open container produce the same results? If boiling water *does* remove odors why do cities not use this method?

Topics	*Understandings*	*Suggested Activities*
b. Pure substances	An *element* is a substance all of whose atoms contain the same number of protons in their nuclei. An element cannot be further decomposed by ordinary chemical means. A *compound* is a substance which is made by the chemical union of two or more elements. In this process, the elements lose their identities. The compound formed may have properties unlike those of either element. Example: Sodium chloride (a white solid) is a compound which is made by the chemical union of the elements sodium (a metal) and chlorine (a greenish-yellow gas).	Direct each pupil's making of a periodic chart. A prepared blank chart may be used for uniformity or each pupil may devise his own. Place the names of the elements in relatively proper order and leave blank those spaces not needed at this time. Students should learn the symbols for some common elements and formulas for some familiar compounds.
IV. Fluids A. Density and Specific Gravity	Density is mass per unit volume and specific gravity is the ratio of the mass of a given substance as compared to the mass of the same volume of water, or air in the case of gasses. These are numerically the same in the metric system. Ex. Density of mercury is 13.6 gr. per cu. cm. and specific gravity is 13.6.	Do experiments on finding specific gravity, letting the students do necessary manipulations and mathematics. Do the cartesian diver experiment as a student activity. Specific gravity should be found by: direct measurement water displacement pycnometer hydrometer balancing columns of liqiuds and/or other methods.
B. Pressure	Distinguish between pressure and force. Force is a push or pull. Pressure is weight or force per unit area. For example: One cubic ft. of water exerts a downward force of 62.4 pounds. At one ft. depth, water exerts a pressure of 62.4 pounds per ft.^{2} or 62.4/144 = lbs/1n^2.	Using a gallon varnish can, punch 3 holes in a vertical line on the narrow side of the can. Fill the can with water. Observe the effect of the pressure as water depth varies.

Activities

Experiment 5:

The density of water is 1 g/ml. That is, 1 ml of water weighs 1 gram. Hence you can find the specific gravity of a substance by finding the weight of 1 ml, and comparing with water. Find the volume of the glass stopper by water displacement. To do this, drop it into a graduated cylinder containing water, and note the rise in the water level. If for example the graduate reading went from 20 ml to 50 ml, the volume of the stopper would be 30 ml. Now divide the weight of the stopper by its volume, and you have the weight of 1 ml. This is the density of the glass. How does it compare with the density of water? In other words, what is its specific gravity?

Prepare a "Cartesian Diver," using a small glass vial and a flat-sided flask almost full of water. Operate by squeezing the sides of the flask. See a physics text for details and explanation.

Can you explain why the formula: "specific gravity of a substance equals the weight divided by its loss of weight in water," should give the same results as the formula: "specific gravity of a substance equals its weight divided by the weight of an equal volume ot water"?

Topics	*Understandings*	*Suggested Activities*
C. Buoyancy	Archimedes' principle: Any object placed in a fluid is buoyed up by a force equal to the weight of fluid displaced.	Experiment 6: "Buoyancy" Materials: A large container of water (tote-tray) Aluminum foil (piece about 2" by 4") Paper clips or tacks for weight Empty metal can Sand (Small beaker 50 ml) Graduated cylinder or measuring cup (100 ml) Small test tube or medicine vial Scale (balance) Activity: Shape the foil into a small boat and float it on the water. Place a few paper clips or a tack in the boat. What happens? Remove the weights and crush the foil into a ball. Put it into the water. What happens? Push the empty can downward slowly in the water. What do you feel? Pour sand into the cup a little at a time. Why does it still float? Each time you add sand what happens to the can? Measure 70 ml. of water into the graduated cylinder. Fill the small test tube to the ¼ mark. Place the test tube in the cylinder. What happens to the water? What is the difference in water level before and after the test tube was added? Pour the sand on to a balance scale (Be sure

Topics	Understandings	Suggested Activities
		you previously balance the scale with a piece of paper to hold the sand). What does the sand weigh? Pour sand into cylinder. If a ml. of water weighs 1 gram, does the weight in grams equal the weight of the displaced water? Try weighing other objects and measuring in water (small rocks and similar items.) List several objects which could be weighed by water displacement more easily than any other way. Research: Look up the word "buoyancy" and Archimedes' principle. Weigh an object in air. Weigh the same object in water. Compare the loss of weight in water to that of the displaced water.
	The downward pull of gravity makes water or air push up on anything placed in it.	Develop Archimedes' principle as a follow-up of Experiment 6. Demonstrate with balloon and metal foil experiments in *Everyday Problems in Science (2)* Assign problems to solve, using the principles incorporating cargo, submarines, boats, etc. as found in text *Everyday Problems in Science (2).*
D. Hydraulics	Pascal's Law: Pressure applied to a confined fluid is uniformly distributed throughout the fluid. The principle holds for both liquids and gases.	Public Activity: Investigate hydraulic systems found at garages, hoists, auto brakes and other power equipment.

Topics

E. Fluids (liquid or gas) in Motion

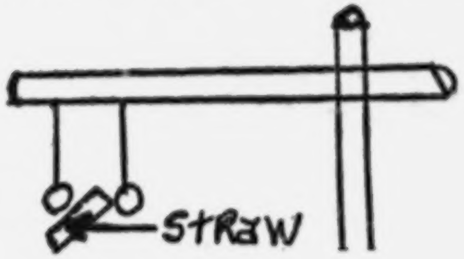
Understandings

Bernoulli's principle: Where the flow is increased, there is a reduction in the pressure at right angles to the direction of the flow.

Suggested Activities

Film: "Harnessing Liquids". Free. Shell Oil Company. See film list, item no. 19.

Student Activity: Suspend two ping pong balls so that they are about 2" apart and on the same level. Blow through a straw between and at a distance in front of them.



Application: How an airplane flies. Hold a piece of paper cambered like an airplane wing on the level with the mouth. Blow on the top surface of the paper. This very simply demonstrates the principle and can be done by each child as a motivating curiosity. Learn the cause of lift as related to airplane flight.

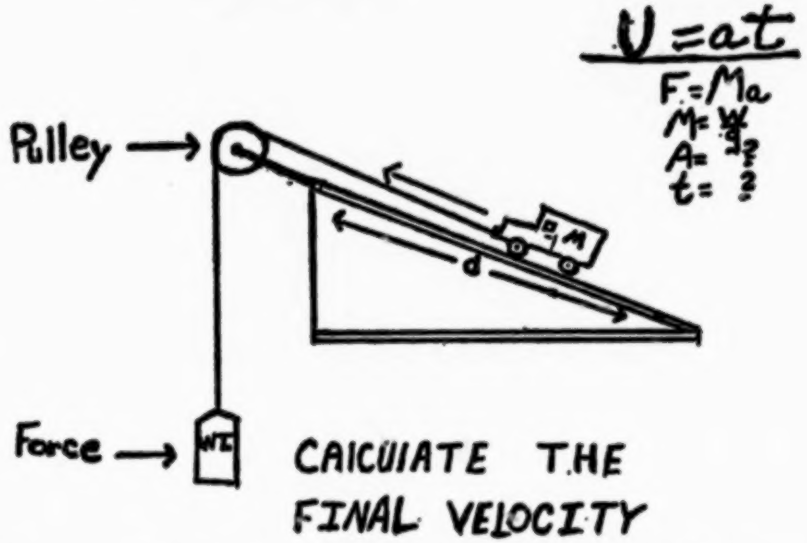
Film: "Lift" from the series "How an Airplane Flies." Shell Oil Co. Free. See film list, item no. 18.

Students should bring to class examples of the principles used in design such as in streamlining autos.

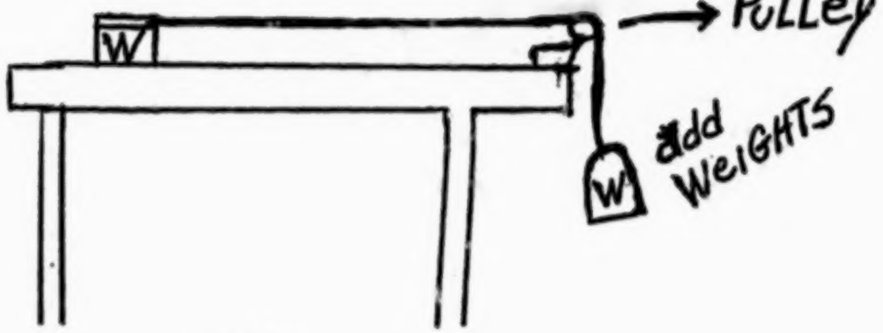
Topics	*Understandings*	*Suggested Activities*
V. Force and Motion		
A. Gravitation and Gravity	Universal law of gravitation: The forces of attraction between any two bodies is directly proportional to the product of their masses and inversely proportional to the square of the distance which separates their centers or $F = \frac{KM_1M_2}{D^2}$	Compare the terms and definitions of mass, gravity, and weight.
	The general inverse square law with a number of applications in physics is $\frac{X_1}{X_2} = \frac{Y_2^2}{Y_1^2}$ Where Y is usually a distance. Other than gravitational attraction, the law is applicable in electric forces, illumination, and nuclear radiation.	Introduce the Inverse Square Law by first introducing the idea of an inverse proportion. Point out that two things are inversely proportional to each other if one increases as the other decreases or if one decreases as the other increases. This may be shown by using the idea of the product of the two things being constant, such $P \times V = C$. Use different values of either P or V and determine the values of V or P once you have given C a particular value. Example: If $C=70$ and $P = 5$, then what must be the value of V? ($V = 14$) Now, still using $C = 70$, but this time $P = 7$, find the value of V. This and another value or two for P should show the student the idea of how one decreases as the other increases. Now point out that from the formula for the force of attraction between two bodies, $F = \frac{M_1 \times M_2,}{D^2}$ as two bodies become farther apart the force

Topics	*Understandings*	*Suggested Activities*
		of attraction between them is changed to the extent that one force is $\frac{1}{d^2} \times$ another force. Example: Suppose the force of attraction, F is 70 dynes when the two objects are one foot apart at their centers. Find the force of attraction, F_2, when the objects are two feet apart. $F_2 = \frac{F}{1} \times \frac{1}{d^2}$ $F_2 = 70 \times \frac{1}{2^2}$ or $F_2 = 70 \times \frac{1}{4}$ or 17.5 dynes. How far would a 70 pound body have to be moved from the earth's surface to weigh only 17.5 lbs.?
	Gravity is a special case of gravitational attraction. There are advantages and disadvantages in gravity. We measure gravity by weight.	Student Activity: Attraction of Bodies. Use any two non-metallic objects hung parallel and same distance from support by a fine thread. Do not let objects touch but have close together. Cut or burn thread of one object quickly. Observe the light swaying motion of remaining object. Air must be very still. Films: "Galileo's Law of Falling Bodies" and "Forces". See film list, item no. 28.

Topics	*Understandings*	*Suggested Activities*
B. Velocity and Acceleration	Velocity is the rate of motion in a definite direction. $V = \frac{d}{t}$ Acceleration is the rate of change of velocity. $a = \frac{\triangle V}{t}$ or $a = \frac{V_2 - V_1}{t}$ Where V_2 = final velocity V_1 = initial velocity Note that either formula works for both positive and negative acceleration.	Student Activity: Have students bring to class all late news reports on records made for all objects in all kinds of travel relating to speed. Student Activity: Plot a car going 0-50 miles an hour in 15 seconds on a graph. Use time as the ordinate and speed as the abscissa. Calculate the rate of deceleration of an object in a given time. Ex.: If a car is traveling 60 miles an hour and comes to rest in 10 seconds, find the rate of deceleration. $t = 10$ sec. $V = 88$ ft./sec. or 60 mi./hr. Find the rate of deceleratin or negative acceleration. $-A = V - 0 = \frac{88}{10} = 8.8$ ft./sec.^{2} or $A = \frac{-88^{t}}{10}$ ft. $= -8.8$ ft./sec.^{2}
C. Newton's Laws 1. Inertia 2. Force-Mass-Acceleration 3. Action and Reaction	Refer to statements of laws in a good text book. Students have an understanding of Newton's laws of motion by definition and application.	The booklet "Classroom Demonstrations" available from Oak Ridge, Tenn., has excellent experiments to illustrate Newton's laws. The film "Isaac Newton" may be purchased. Coronet Films. See film list, item 29. Bell Telephone has available a lecture demonstration entitled "Adventures in Space." Student Activity: Write a story about the experiences one might have in space. The Filmstrip "Newton's Laws" is an excellent source for material to adapt to an open end experiment.

Topics	*Understandings*	*Suggested Activities*
	These laws are essential to modern space exploration. The acceleration is proportional to the force and inversely proportional to the mass, therefore $a = \frac{F}{m}$	Student Activity: Force — mass acceleration: With a stop watch record the time required for an object to be accelerated up an incline as shown in this diagram.  V=at F=Ma M=W/g A=? t=? Pulley M d Force WT CAICUIATE THE FINAL VELOCITY
VI. Energy, Work, and Power A. Energy	Energy is manifested in the form of chemical, radiant, nuclear, mechanical, and electrical. It is found as potential and kinetic. Energy can be converted from one form to another. The sum total of energy is constant.	Filmstrip. "Energy", free, Am. Petroleum Company. Refer to the following texts for experiments on this unit. See no. 60. Explain the formulas: $PE = wh$ $KE = \frac{1}{2}mv^2$ $m = \frac{w}{g}$

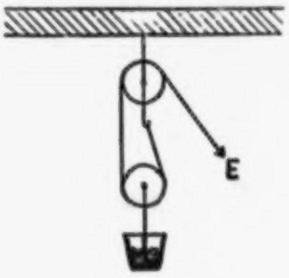
Topics	*Understandings*	*Suggested Activities*
Energy (Continued)		Reference: Pendulum Experiment in Handbook. Bell Telephone may offer free, one to each school, two kits entitled, "Energy From the Sun" and "From Sun to Sound." See film list, items no. 11 and 15, "Our Mr. Sun" and "The Science of Sound."
	Law of Conservation of matter: Under ordinary circumstances neither mass nor energy is created or destroyed, but is changed from one form to another. (Nuclear energy will be developed in the last unit.)	Student Challenge: Project: Have students perform experiments which will develop a series of energy conversions. Begin with sunlight; convert to other forms in a cycle. Experiment 7: "Chemical Energy" Materials: General photographic flash bulbs, triple beam scale balance, source of current, (two or three 1½ volt batteries.) Objective: To observe the law of Conservation of Mass and Energy. Procedure: Weigh bulbs before and after being fired (burned out) and record weights. Open to discussion—Why?
B. Work 1. Definition	Force is any influence capable of altering the state of rest or motion of a body. (Refer to Newton's first law).	
	When a force acts through a distance work is done.	Do problem studies in work. (1) classroom (2) home
2. Forms of resistance that oppose work	There are three forms of resistance that oppose work: inertia, gravity, and friction.	Ex.: How much work does a 100 lb. boy do climb a stairway 10 ft. high? Observe the force of static and sliding fric-

Topics	*Understandings*	*Suggested Activities*
		tion when a block is pulled along a table surface by suspending weights over a pulley. Use care not to accelerate the body. 
		Texts:
		Films and Visual Aids:
B. Work (continued) B. Work of Simple Machines	All complex machines are combinations of simple machines.	Student Activity: Let students work in groups to study and demonstrate machines found in the home. (simple and complex machines).
a. Levers 1. first class	The fulcrum lies between the effort and resistance force.	Student Problem: Two boys weighing 80 and 100 lbs. are balanced on a 12' see-saw. By the use of moments of force, determine the distance of the fulcrum between the two boys. Clockwise moments equal counter clockwise moments: cw. $m_1 = W_1D_1$ ccw $m_2 = W_2D_2$ $D_2 = 12 - D_1$

Topics	*Understandings*	*Suggested Activities*
		$100 \text{ lbs} \times D_1 = 80 \text{ lb.} (12 - D_1)$ Determine D
2. Second class	The resistance force lies between the effort force and the fulcrum:	The resistance load in a wheelbarrow weighs 300 lbs. and is located 1½ ft. from the fulcrum. If the handles of the wheelbarrow are 4½ ft., determine the effort needed to lift the wheelbarrow when lifting at the very end of the handles.
3. Third class	The effort force lies between the fulcrum and the resistance force.	Find the weight of a fish which is being lifted by a 14' pole if the effort force of 100 lbs. is exerted 2' from the end of the pole.

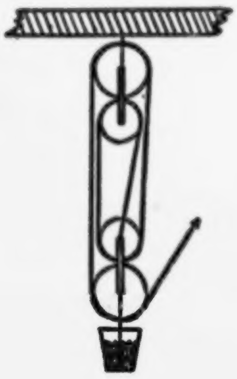
PULLEYS

Single Fixed Pulley and Single Movable Pulley



1. Set up a system as in Fig.
2. Record the amount of effort force needed to raise a resisting force of about 4.9 lb. (Remember to raise the resisting force with a slow uniform speed after giving it a slight start.)
3. Record the distance the effort force moves in order to raise the resisting force 10 cm.

Double Fixed and Double Movable Pulley



1. Set up a system as in Fig.
2. Record the amount of effort force needed to raise a resisting force of 9.8 lb. (approx.).
3. Record the distance the effort force moves if the resisting force is raised 10 cm.

OBSERVATIONS

1. The ideal mechanical advantage of a pulley system can be easily determined by:
   a. — — — — —
   b. — — — — —
2. Why is the efficiency of the pulley system not 100%?
3. If a person were holding a 50 Kg object by means of a single fixed pulley, how much work would he be doing?
4. How far must the effort force move if the resisting force is moved 8 cm? Suppose you were using a single fixed and a double movable pulley combination.
5. A block and tackle is found to raise a weight 3 meters when the effort force moves 15 meters. The effort force is 60 newtons and weight is 225 newtons.

   Note—Force (Newtons) = Mass (Kilograms) × a (Meters Per Sec.$_2$

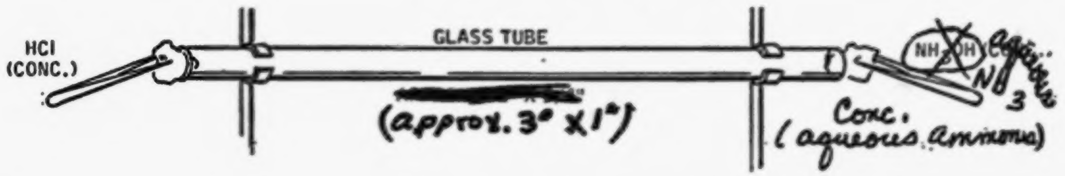
   a. The actual mechanical advantage is ____________.
   b. The ideal mechanical advantage is ____________.
   c. The work input is ____________.
   d. The work output is ____________.
   e. The efficiency of the block and tackle is ____________.
6. Does a pulley system save work?

Topics	*Understandings*	*Suggested Activities*
4. Mechanical advantage	A machine may be used to an advantage either to accomplish an increase in force or speed. However, an increase in one represents a corresponding decrease in the other.	By use of machines (pulleys, levers, wheel and axle, inclined plane) Determine the actual MA Make necessary measurements for the theoretical MA Calculate the efficiency Allow students to explore on different machines and arrive at special formulas for TMA.
5. Efficiency	$\text{AMA} = \frac{\text{R, Resistance}}{\text{E, Effort}}$ $\text{TMA} = \frac{\text{DE, Distance Effort Moves}}{\text{DR, Distance Resistance Moves}}$ $\text{Eff.} = \frac{\text{AMA, Actual Mechanical Advantage}}{\text{TMA, Theoretical Mechanical Ad.}}$ Pulley = The efficiency of a pulley system	Student Activity: Let students run up and down steps, where practical, and determine horsepower. Using weight as the force, would distance be the length or height of steps?
6. Power	The element of time is necessary to determine power. $\text{Power} = \frac{\text{force} \times \text{distance}}{\text{time}}$ 1 HP = 550 ft. lbs./sec. or 33000 ft. lbs./min.	To find horsepower of an automobile Multiply the mass of the car $\frac{(\text{wt})}{g}$ by the acceleration and then by the distance moved. Divide by the time. This will give the power of the car. Apply the horsepower formula to calculate the horsepower. Note—maximum acceleration is assumed. Write to an automobile manufacturer requesting a bulletin on power rating of engines. Student Activity: An elevator can lift a load of 4000 lbs. to a height of 100' in 20 sec. What is the HP?

Topics	*Understandings*	*Suggested Activities*
VII. Heat A. Kinetic theory (including gas laws)	Radiant energy increases molecular activity.	Student Activity: Students may experiment with heating and then cooling a. balloon, b. stoppered test tubes with water or air, also c. heating an open flask then placing a stopper inside the flask. Student Activity: Place copper sulfate in two test tubes of water. Place one aside, do not disturb. Heat the other tube. Observe the movement of materials in the water. Do the same experiment with potassium permanganate.
	Thermal energy will move from a body having greater average kinetic energy of its molecules to a body of less average kinetic energy of its molecules.	OPEN END EXPERIMENT: Obtain a glass tube 3' long by 1" diameter. Fit wads of cotton into the ends of the tube that have been soaked with concentrated hydrochloric acid and concentrated aqueous ammonia respectively. Put them into the tube simultaneously. A white cloud forms when the diffusing gases combine. Note the difference in the distance from the ends of the tube that the cloud forms. Try varying the temperature of the soaked cotton. Con sider changing other environmental factors. Activity: Place a container of odorous liquid like ether or butyric acid at the center of the room. This should be done with the window closed and the cooling or heating turned off to prevent air currents from carrying the odor. At a given signal uncap the container and with someone counting

the seconds out loud, each student records the time it takes for him to smell the odor. Measure or estimate your distance in feet to the odor source; then determine the rate of speed the odor was traveling as shown below.

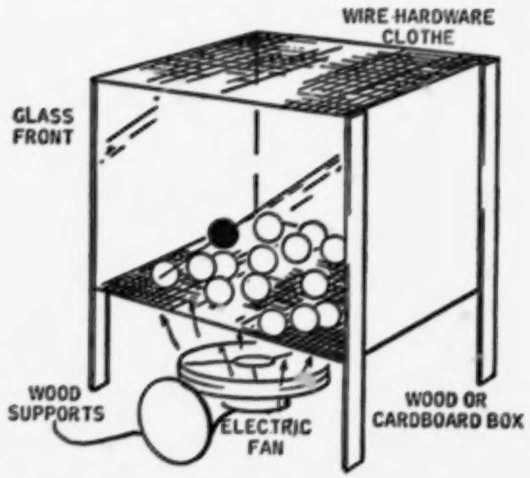
$$\frac{\text{Distance to odor (Ft.)}}{\text{Time to travel (sec.)}} = \text{Ft./Sec.}$$



How can we explain diffusion phenomena?

a. Observe ten or more ping-pong balls as they are blown by a fan in the apparatus shown here. If one ball is colored with ink its motion can be followed. This demonstration should give a clue to the Kinetic Molecular Theory. Can you tell how it explains diffusion phenomena? DISCUSS . . .

Reference:
Investigations in Physical Science by Warren Strickland, Burgess Publishing Co.



Topics	*Understandings*	*Suggested Activities*
		EB Film "Atmosphere Pressure"
B. Specific Heat and Thermometry	Equal weights of varying materials contain different amounts of thermal energy.	Take two pans with unequal amounts of water, heat at same rate with a heat source such as a goose-neck lamp. Measure temperature and note differences.
	Thermometers measure the temperature of a material, not heat.	
	The specific heat of a substance is expressed in relation to that of water, the standard, which is 1. When water cools 1° C. each gram would impart 1 calorie. When iron cools 1° C. each gram would lose only .1 calorie. Ex.: copper .09 iron .10	Make simple calculations to determine amount of heat transfer to or from liquids by changes of temperature. Develop an understanding of the relationship between Kelvin, Centigrade, and Fahrenheit. Fahrenheit = 9/5 C + 32, K = Centigrade + 273 For further information on Kelvin consult: *Science—A Key to the Future.*

Topics	*Understandings*	*Suggested Activities*
		Atomic weight may be calculated from the formula: Specific heat of a substance times a constant 6.4 = atomic weight. Extra Activity for Advanced students: Determine the atomic weight of an element. Determine the molecular weight of a compound. Information concerning this activity may be found in a chemistry text of recent publication.
C. Calorimetry and Heat Transfer	Develop the understanding of heat transfer in each method: conduction, convection, radiation. These methods are not isolated but usually found in combination with each other.	Find unusual examples of heat transfer. Student Activity: Devise an experiment showing as many examples of heat transfer as possible, using all three methods.
	Know the conversion of BTU and calorie measurement — Develop the idea that calorie and BTU are measures of amount of heat. 1 BTU = 252 calories	Students may bring reports on: Insulating homes and equipment Air conditioning or refrigeration Special heating systems. Have the students make a calorimeter. Consult a high school physics book for a diagram.
		HOW IS HEAT MEASURED? Hidden heat and temperature: a. A student or team of students will perform this investigation by preparing two identical beakers. *Beaker # 1* will have ice water with one cube of ice and a thermometer. *Beaker # 2* will have ice water with ice cubes and a thermometer. The beakers

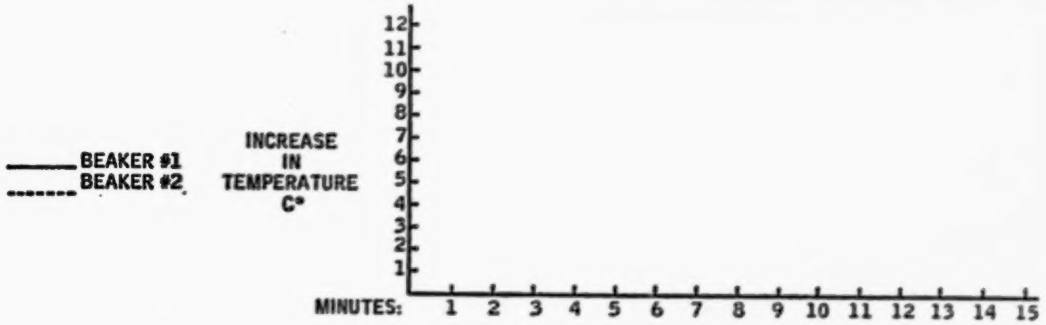
Topics

Understandings

Suggested Activities

should be weighed and water added to make them weigh the same.

b. An electric fan placed equidistant from both beakers will help. Before the ice cube in beaker #1 has melted, record the temperatures of both beakers. Continue this for about ten minutes or until all ice cubes are melted. Record the information below.

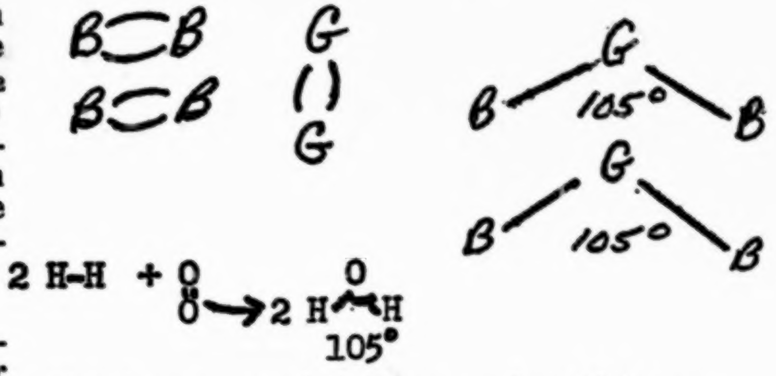


c. Since both beakers were absorbing equal amounts of heat, what do you think happened to the heat that was absorbed by beaker #2? DISCUSS . . .

d. What was the thermometer really showing?

e. Does the temperature tell us about the hidden heat, called "latent heat", that was absorbed? DISCUSS . . .

Topics	*Understandings*	*Suggested Activities*
D. Mechanical Equivalent of Heat	Mechanical equivalent of heat-ratio of work done to heat produced. 1 BTU = 778 ft. lbs. work Many machines operate because of heat principles. steam engine gasoline engine gas turbines	Field trip to a steam generating plant or speaker from the plant is beneficial. These are available from public utility companies. Students can build models of heat machines and operate them. Examples: Hero's Engine, steam engine, and gasoline cylinder. Film: Mechanical Energy and Thermal Energy (Modern Learning Aids) See film list, item no. 2.
VIII. Introduction to Chemistry: A Few Basic Concepts A. Atomic Structure 1. proton 2. electron 3. neutron B. Terms 1. Atomic number 2. Atomic weights 3. Isotopes 4. Periods (periodic table) 5. Groups (periodic table) 6. Others	The three subatomic particles of most importance to the chemist are the proton, the neutron, and the electron. The proton and the neutron are located within the nucleus, the electron outside the nucleus. Students should be able to understand the terms: atomic number, atomic weights, isotopes. Lead students to follow formation of isotopes, noting that the number of protons remains the same, but the number of neutrons increases.	Construct a Hubbard chart of the elements. Use G. E. Film "A is for Atom". Also use G. E. "funny book" *Inside the Atom.* Make use of free materials available from the Atomic Energy Commission, Oak Ridge, Tenn. Add atomic number and atomic weight to previously made periodic chart. Make models of isotopes of hydrogen or others. Special reports by students and diagrams of other isotopes.
C. Electron Configuration	Electrons are present in the extra-nuclear space of an atom, where there are definite energy levels, often called shells. The farther the electron is from the nucleus the greater its energy. Elctrons are said to fill orbitals, a term designating a region of space, having a definite geometric shape. In the simplest atom, that of hydrogen, the region of space which the electron occupies is spherical. It is called the 1 s orbital.	

Topics	*Understandings*	*Suggested Activities*
D. Valence 1. Definition 2. Examples	Valence, or oxidation number, is the numerical combining capacity of one element with another. The valence of an atom is determined by the number of electrons it gains, loses or shares in a chemical reaction. Some elements exhibit more than one combining capacity. Iron, for example, forms two different kinds of compounds, those in which iron has a valence of +2 and those in which it has a valence of +3. ($FeCl_2$ iron II chloride; $FeCl_3$ iron III chloride.) Often, *but not always*, the valence of an element is the same as its group number in the periodic table. In aluminum chloride ($AlCl_3$), aluminum, in Group III, has a valence of 3.	Illustrate the combination type of reaction below. $2H_2 + O_2 \rightarrow 2\,H_2O$ Use four boys to represent the four atoms of hydrozen (two molecules), two girls to represent two atoms of oxygen.  $2\ \text{H–H} + \begin{matrix}\text{O}\\ \|\\ \text{O}\end{matrix} \longrightarrow 2\ \underset{105^\circ}{\overset{\text{O}}{\text{H}\frown\text{H}}}$
IX. Inorganic Compounds A. Acids 1. Arrhenius 2. Brönsted 3. Lewis	According to Arrhenius an acid is a substance that gives hydrogen ions in water solution (H+). H+ ions of acids affect litmus by changing the color to red. An Arrhenius base is a substance that gives hydroxyl (OH—) ions in a water solution. The term acid has had various meanings throughout the years. Lavoisier thought that all acids contained O_2. Later, it was proved that hydrochloric acid contains no 0_2. Today, there are many concepts of the term acid.	This is an example of the way in which various chemical reactions can be illustrated in the classroom. Verify the statements of the understandings by testing fruits and common liquids in the home and school environment, for acidity and basicity. Examples of liquids: liquid soap vinegar household ammonia Write formulas for various Arrhenius acids and bases. Name each.

Topics	*Understandings*	*Suggested Activities*
Inorganic Compounds (Continued)		
B. Bases	Modern acid-base theory includes, in addition to the Arrhenius concept, several others. Brönsted and Lewis are among the most important. Hydroxide ions (OH—) of Arrhenius bases, affect litmus by changing the color to blue. Neutralization, according to the Arrhenius concept, involves the production of water.	Prepare a solution of sodium hydroxide by dissolving (approximately) 1 gram of NaOH in 50 ml. of distilled water. Using 5 ml. of this solution, neutralize by adding dilute HCl drop-wise. Use red and blue litmus paper to determine when neutralization occurs. Evaporate the resulting solution to dryness. What is the solid material left in the evaporating dish? This activity may be repeated and varied by using other bases and acids.
C. Salts	The other product of the reaction (besides water) is called a salt.	

Examples: $\longrightarrow \underset{\text{(base)}}{\cancel{Na^+} + OH^-} + \underset{\text{(acid)}}{H^+ + \cancel{Cl^-}} \rightarrow \underset{\text{(salt)}}{\cancel{Na^+} + \cancel{Cl^-}} + H_2O$

Simplified: $H^+ + OH^- \longrightarrow \underset{\text{(not ionized)}}{H_2O}$

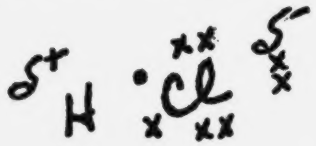
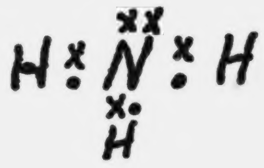
$\underset{\text{(base)}}{\cancel{K^+} + OH^-} + \underset{\text{(acid)}}{H^+ + \cancel{NO_3^-}} \rightarrow \underset{\text{(salt)}}{\cancel{K^+} + \cancel{NO_3^-}} + H_2O$

Simplified: $H^+ + OH^- \longrightarrow \underset{\text{(not ionized)}}{H_2O}$

Note that water is produced in each case.

KNO₃ (potassium nitrate) and NaCl (sodium chloride) are salts. These compounds are *ionic* in nature. Water is *molecular*, (non ionized, except very, *very* slightly).

	Understandings	*Suggested Activities*
D. Oxides 1. Metallic 2. Nonmetallic	If the name of a chemical compound ends in "ide", it usually contains *only* two elements. (Exception, hydroxides).	Burn a small piece of magnesium ribbon. The white powder which results is magnesium oxide (MgO).
	Oxides, then, are compounds, containing oxygen and one other element. Common metallic oxides are: quicklime, calcium oxide (CaO) iron rust (an oxide of iron.)	Try to dissolve the white powder in water. Test the solution with litmus.
	Examples of nonmetallic oxides are: carbon dioxide (CO_2) carbon monoxide (CO) sulfur dioxide (SO_2)	Ignite a small quantity of sulfur in a combustion spoon. Lower the burning sulfur into a wide-mouth bottle. The white fumes are SO_2 (sulfur dioxide), and SHOULD NOT BE INHALED.
		Add a few drops of water to the bottle. Cover the bottle with a glass plate. Carefully shake the bottle, to aid dissolving. Test the liquid in the bottle with litmus.
		Metallic oxides which dissolve in water form what? Nonmetallic oxides which dissolve in water form what?
X. Chemical Bonding A. Definition	The term ***chemical bond*** refers to the force that holds atoms together in a molecule, ions together in a crystal.	Illustrate the various types of bonds, using simple compounds. Examples:
B. Types of Bonds 1. Covalent (a) polar (b) nonpolar (c) coordinate covalent	Most chemical bonds belong to one of two main classes: *covalent* *electrovalent*	(1) nonpolar covalent H : H (the hydrogen molecule)

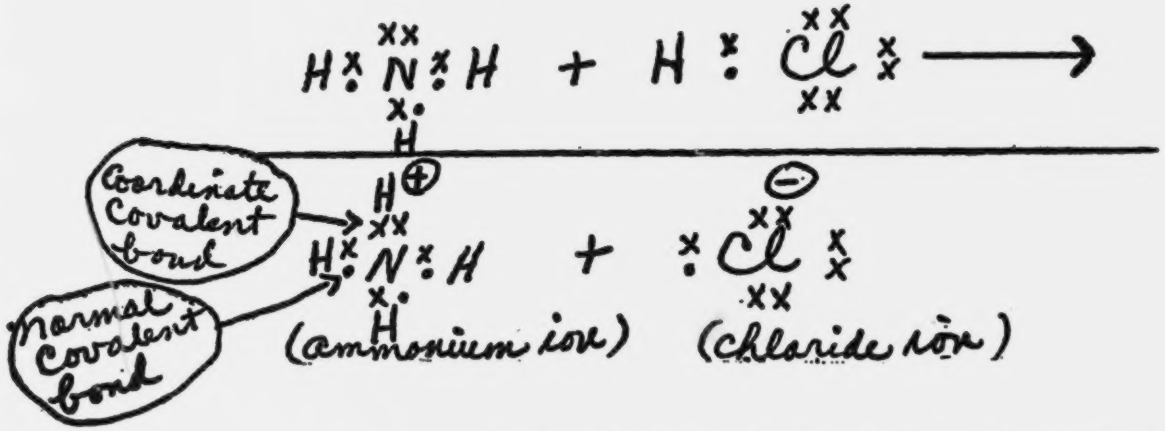
Topics	*Understandings*	*Suggested Activities*
2. Electrovalent (ionic)	However, there are *other* types of bonds encountered when one studies chemical bonds in detail. One of these is the hydrogen bond.	
3. Others	Elements differ in their *electronegativity*, (power to attract and hold electrons.)	When a molecule is composed of two *like* atoms, the bond is formed by *equal* sharing of the two electrons. Such a bond is said to be *nonpolar covalent.*  (Polar Covalent) The chlorine atom has greater electronegativity than hydrogen. The compound HCl is said to be polar covalent, having a slightly positive (S^+) and a slightly negative (S^-) end. In *normal covalent bonds*, each atom provides an electron for the bond, as in the example above. (The chlorine electrons are designated by the symbol x.) In *coordinate covalent bonds*, both electrons making up the bond are provided by the same atom. 

Topics

Understandings

Suggested Activities

(The ammonia molecule)
Note the unshared electrons on the nitrogen atom ($N^{\times\times}$). When ammonia reacts with HCl, the proton of the hydrogen atom is attracted to these electrons, and a *coordinate covalent bond* is formed, as shown below.


Coordinate Covalent bond
Normal Covalent bond
(ammonium ion)
(chloride ion)

Both electrons of the coordinate covalent bond originally belonged to the nitrogen atom.

In ionic or electrovalent bonds, an electron is actually transferred from one atom to another. (See illustration of formation of KCl, page 224.)

Topics

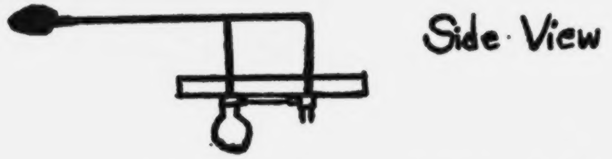
XI. Conductivity of Solutions

Understandings

Electrolytes conduct electricity. Nonelectrolytes do not. In the suggested activity on this page, $Ba(OH)_2$ (barium hydroxide) is shown to be an electrolyte. (The light burns.) It is also an Arrhenius base, as indicated by the use of the *indicator* phenolphthalein. As H_2SO_4 (sulfuric acid) is added, insoluble $BaSO_4$ (barium sulfate) is formed. *Precipitation* of this substance removes from the solution barium ions and sulfate ions. When the light goes out, Arrhenius *neutralization* has occurred, as shown by the formation of water. (See equation.) The solution no longer conducts electricity, as the electrolyte has been removed from the solution by *precipitation.*

Suggested Activities

Connect sockets in *series* with 6 to 8 foot lamp wire and regular male plug. In one socket, place a 40 watt (or smaller) bulb and in the other, a bulb with the glass and filament removed. Care should be used not to touch the bare electrodes when circuit is closed.



When plugged into the house circuit, wires of the "burned-out" bulb may be brought in contact with various solids and liquids to determine conductivity.

Prepare barium hydroxide solution, which is barium oxide in water, in a glass container. Slowly add with constant stirring dilute sulfuric acid. (Add a little phenolphthalein indicator if desirable.) Keep wires of conductivity apparatus submerged in the solution at all times. As the sulfate ions and barium ions precipitate as barium sulfate, the light gets dimmer and dimmer, as does the pink color. On neutralization, light goes out and color disappears. Excess bisulfate ions and hydrogen ions cause the light to brighten.

$$Ba^{++} + 2OH^- + 2H^+ + (SO_4)^{--} \rightarrow$$

$$\underset{\text{(precipitate)}}{BaSO_4 \downarrow} + 2H_2O$$

Topics

XII. A Classification of the Elements
  1. metals
  2. nonmetals

Understandings

Metals comprise a group of elements (other than hydrogen) whose atoms have a tendency to lose electrons readily and may be arranged in an activity series according to their tendency to pass into ionic form by losing electrons.

Nonmetals comprise a group of elements whose atoms tend to gain or share electrons and may be arranged in an activity series according to their tendency to pass into ionic forms by gaining electrons.

Elements ending in —ium are metals. Elements ending in —ine are nonmetals.*

Amphoteric elements may behave as metals or nonmetals.
Ex.: carbon, silicon, hydrogen.

Suggested Activities

Consult the activity series for metals and nonmetals of the atomic chart for verification and exercises.

Student Activity:
What other ways could the elements be classified? Ex. color, crystallization, etc.

Using the metals below, arrange in order of decreasing activity, by observing their reactions with a solution of dilute sulfuric acid. Use the same volume of acid in each case and approximately the same weight of the metal.

REACTION

	None	Slight	Moderate	Vigorous
Copper				
Zinc				
Magnesium				
Iron				

---

*Helium is an exception to this rule.

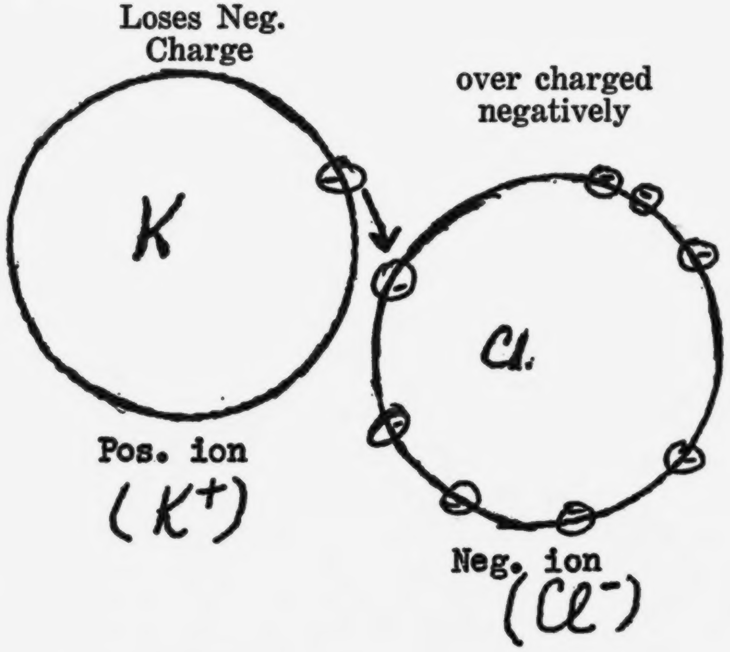
Topics

Understandings

Suggested Activities

Use an illustration such as:

Potassium atom


Loses Neg. Charge
over charged negatively
K
Cl.
Pos. ion
(K+)
Neg. ion
(Cl-)

(—) electron

This transfer of the electron of K to Cl is an example of electrovalence.

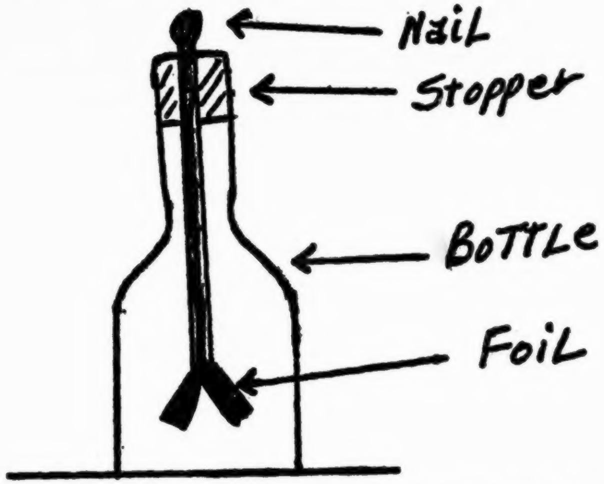
Potassium chloride is formed.

Topics	*Understandings*	*Suggested Activities*
XIII. Chemical Reactions		
A. Atomic weight	Explain how a molecule can be a single atom or a combination of two or more atoms. Recently the standard for comparison of atomic weights changed from oxygen to carbon 12. While this does not change the actual weight of the elements, the relative weights are slightly altered.	Illustrate single atoms used as molecules, in board study and desk exercises. Refer to recent textbook. Calculate formula weights of: elementary substances, as O_2 compounds, as $KClO_3$ One atomic weight of K 39 One atomic weight of Cl 35.5 (One atomic weight of O_2) $\times 3 = 48$ Formula weight of $KClO_3$ $= 122.5$
B. Formula weight	The term, formula weight, refers to the sum of the atomic weights of all the atoms present in the formula. Example: The formula for nitrogen gas is N_2 There are 2 atoms of nitrogen in the formula. Each one weighs (approximately) 14. Therefore, the formula weight is $14 \times 2 = 28$.	Student Activity: Have a student show how Dalton's theory has been developed and expanded in recent years.
C. Definite combining ratios	Elements that form compounds do so in definite combining ratios by weight. One way of stating the *Law of Definite Proportions* is to say that "the chemical composition of a compound never varies." Water always contains two atoms of hydrogen and one atom of oxygen per molecule. The ratio 2:16 or 1:8 is constant. (Two parts by weight of hydrogen combine with 16 parts of oxygen.)	What is the ratio by which the elements in the following compounds combine? carbon monoxide carbon dioxide hydrochloric acid (others)

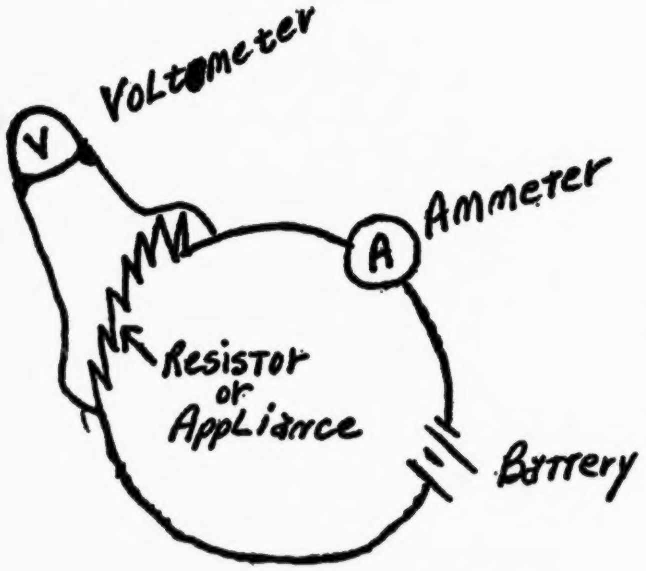
Topics	*Understandings*	*Suggested Activities*
D. Evidence of Chemical Reactions	Chemical reactions may or may not be evident.	
	Many chemical changes result in noticeable energy and physical changes.	
	Reactions which absorb heat are *endothermic*. Those reactions which give off heat are *exothermic*.	Student Activity: Using a very small flashlight bulb (1.5 volt), attach a strip of magnesium ribbon to the terminal on the bottom of the bulb. Attach a conductor (Cu wire) at the other terminal—around base of bulb. Hold the bulb over a dilute solution of sulfuric acid so that the ends of the ribbon and wire extend into the solution. Observe the results. Endothermic reaction: Heat HgO Exothermic reaction: Pour concentrated sulfuric acid on sugar.
E. Some types of chemical reactions 1. Combination reactions 2. Decomposition 3. So-called displacement reactions 4. Oxidation-reduction reactions	If elements unite directly to form a compound, the reaction is called *combination*. When wood burns, carbon unites with oxygen of the air. $C + O_2 \rightarrow CO_2$ If a compound is broken down into its component parts, *decomposition* occurs. Priestley decomposed mercuric oxide by heating it.	Demonstrate destructive distillation. Field trips to industrial chemical plants are helpful.
F. Effect of catalysts on reactions	$2\ HgO \xrightarrow{\Delta} 2\ Hg + O_2$	Show that MnO_2 (manganese dioxide) has a catalytic efect on the *thermal decomposition* of $KC1O_3$. Heat a sample of $KC1O_3$ in

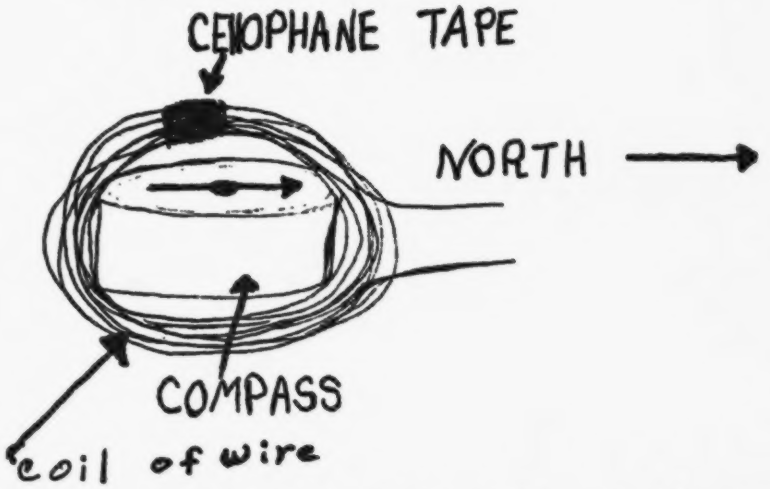
Topics	*Understandings*	*Suggested Activities*
	Active metals are said to "*displace*" hydrogen from dilute solutions of some acids. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$	a test tube, and test for the evolution of oxygen.
	Many reactions are classified as *oxidation-reduction* reactions. *Oxidation* is any process in which electrons are lost; reduction is any process in which electrons are gained.	Heat a similar sample of $KC1O_3$ to which a small quantity of MnO_2 has been added. Test for O_2 (See experiment in Part IV)
	Refer to the diagram showing the formation of KCl on p. 224.	Place a clean nail in a solution of $CuSO_4$ (copper sulfate), using another solution of $CuSO_4$ as a control. Look for evidence of *displacement*.
XIV. Electricity at Rest		
A. Nature of Electric Charge	Electrical nature of all matter	Review structure of the atom, using charts and models.
B. Charged bodies	Charges result from excess or deficiency of electrons in a body. Electrons pass freely between certain bodies.	Rub a balloon against wool, nylon, hair or other clothing. Observe attractive properties of a balloon. Hold the charged balloon over powdered iron or over saw dust. Have students rub comb through dry hair. Show attraction for bits of paper. Students should observe or recall results of static charges. Ex: Shocks obtained from contact with metal part of car after sliding on plastic seat. Clothing sticking to body, Sparks in the dark from combing hair, Heavy spark discharges created by electrostatic generator such as the Van de Graaf generator.
	Excessive static charges may cause fire, dust explosions or fatalities such as charges on oil trucks, in chemical plants, or in case of lightning.	Reports may be given on: Lightning rods. Drag chains on oil trucks.

Topics	*Understandings*	*Suggested Activities*
C. Conductors and Insulators	Conductors are bodies or substances which permit a free flow of electrons. Insulators do not permit a free flow of electrons within the body or to adjacent bodies.	Experiment — Devise an experiment to test conductivity of liquids and solids. Construct an electric circuit using cell, battery, or possible house current for power, a lamp bulb of matching voltage. Insert materials to be tested at gap in the circuit. Collect materials and classify them from above tests. Collect commercial insulators and compare as to voltage which can be effectively insulated.
D. Electrical Attraction & Repusion	Similarly charged bodies repel one another. Unlike charges attract.	Rub two balloons with a cloth. Suspend the balloons side by side with string. Observe action of pith balls (which can be obtained from the heart of a corn stalk) when charged bodies are brought near. Have students construct similar apparatus using puffed wheat or puffed rice and thread. Student Activity: Construct an electroscope. Attach a 3" strip of foil from a gum wrapper to the end of a nail inserted through a stopper which fits into a small necked bottle. (See diagram next page.)

Topics	*Understandings*	*Suggested Activities*
		 Bring various charged objects near the head of the nail. Charge a rubber rod and bring near the knob of an electroscope. Have students explain observations. Have students perform similar experiments with strips of newspaper. Observe an electric whirl (accessory to Van de Graff generator) and interpret rotation of electric whirl.
E. Electrical fields	Electrical fields exist in the proximity of charged bodies.	Film: Magnetic, Electrical and Gravitational Fields (EB) See film list, item No. 24. An electrical field may be visualized by sifting pencil sharpener sawdust on a glass plate which is placed over the top of the Van de Graaff generator.

Topics	*Understandings*	*Suggested Activities*
		Consult the indexes of physical science books and find the uses of electric fields. Film: A Magnet Laboratory, Modern Learning Aids.
XV. Magnetism		
A. Nature of Magnetism	Magnetism occurrs in certain substances when molecules (in domains) align themselves in the same direction.	Student Activity: Break a stick magnet into several short pieces. Observe the polarity to verify the domains. Using a compass, check polarity at the bottom and top of an iron structure.
B. Terrestrial Magnetism	Magnetism occurs in nature, i.e., terrestrial magnetism. (magnetic poles of the earth) and lodestone.	Illustrate the earth's magnetic field by suspending a bar magnet on thread and observing the earth's polarity.
C. Magnetic Attraction and Repulsion	Unlike poles atract and like poles repel.	Demonstrate by suspending two magnets near each other. Also magnetic toys may be brought from home.
D. Magnetic Fields	The magnetic field is the region about a magnet which has intensified lines of force.	Show how the "inverse square law" applies in the strength of a magnetic field. Student Activity: With a magnet fixed at a given distance above a piece of iron which has been balanced on the pan of a triple scale balance, vary the distance of the magnet and observe the atractive or repulsive force on the scales. Sprinkle iron filings over a flat piece of paper which is lying over a bar magnet. Tap the paper lightly until filings fix themselves with lines of force. Use paraffin wax or hair spray which contains lacquer to fix filings to paper for permanent display.

Topics	*Understandings*	
XIV. Electricity in Motion		Film: *Electrochemistry* — EB. See film list, item No. 22.
A. Chemical Energy	Cells and batteries are used to store chemical energy.	Make a complete circuit using battery, flashlight bulb and switch. Select other resistors for experimentation.  Voltometer V A Ammeter Resistor or Appliance Battery Be sure meters are properly connected to the circuit.
B. Current and Charge	Static electricity is an accumulation of positive or negative charges. Current electricity is a flow of electrons along a conductor.	Class project: Obtain a voltmeter, ammeter, and variable resistor. Use a source of electricity and study the relationship between voltage, amperage, and resistance.

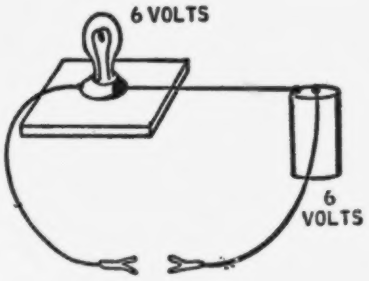


Topics	*Understandings*	*Suggested Activities*
	An electron is an electric charge and electric charges in motion constitute an electric current.	Students should find out how a galvonometer is constructed, make one, and illustrate its use.
C. Voltage	Voltage (potential difference, E.M.F., etc.) is a condition which will cause current to flow (elec. current). The teacher should avoid the idea that voltage flows *through* a conductor.	Film — *Electromagnetic Waves*, Modern Learning Aids — *What is an Electric Current?* (EB) See film list, item 21. Make measurements and verify facts. Refer to the class activity above.
D. Resistance	Resistance is an opposition to the flow of electricity. It reduces the quantity of electrons flowing per second.	Allow students to measure the resistance of various materials (voltmeter-ammeter method). Also, measure resistance in cold and hot materials—Make a simple rheostat. Insert several resistors in a circuit and study the change in current.

DISCOVERING ELECTRICAL MEASUREMENTS*

The story of the discovery of electricity is not only a fascinating story of the past, but it also describes the pattern of experimentation that even today sets the pace for modern research. When you wish to enjoy an occasional evening of good interesting reading, read in your school's library books about some of the following early investigators of electricity: Volta, Oersted, Ampere, Ohm, Faraday, Henry, Gauss, Hertz, Edison, Fleming and DeForest.

WHAT IS THE RELATIONSHIP OF CURRENT TO VOLTAGE?



In the following experiments your teacher will use an electrical test circuit like the one shown at the right.

a. Complete the test circuit by touching the clips together. Note the brightness of the blub, remembering that the brightness of the bulb depends upon the amount of current (electrons) that flows through the filament of the light bulb.

b. Now stubstitute a *1½ volt* battery for the *6 volt* battery. Again note the brightness of the bulb.

c. What do you think this shows about the way current varies with the voltage?

d. Is there a mathematical expression for this relationship? DISCUSS.

current (=) (is proportional to)

WHAT IS THE RELATIONSHIP OF CURRENT TO RESISTANCE?

Using the 6 volt battery in the test circuit, add a 12 inch section of coiled nichrome resistance wire to one clip. Nichrome wire is used in hot plates and toasters.

a. Now take the other clip and move it along the resistance wire towards the other clip. Observe the light bulb and note how it varies with the amount of resistance offered by a greater or lesser amount of resistance wire in the circuit.

b. What do you think this shows about the way current varies with the resistance?

c. Is there a mathematical expression for this relationship? DISCUSS.

Current (=)

OHM'S LAW

A German physicist, George S. Ohm, in the early 1800's, noted the relationships that you have observed above and combined them into a single mathemtical expression or formula. Can you also discover that formula? Try it! DISCUSS.

Current = ________________

UNITS: Current (measured in *Amperes* of current); Voltage *(volts);* and resistance *(ohms).*

APPLYING OHM'S LAW

Many electrical problems can be solved using Ohm's Law.

a. If you were designing an electric toaster that was to use a current of 5 amperes and be used on 110 volt house current, how much resistance would the resistance wire have to offer?

________________ohms.

b. What current is used by a lamp that has a restistance of 55 ohms and uses house voltage of 110 volts?________________amperes.

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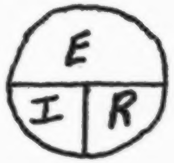
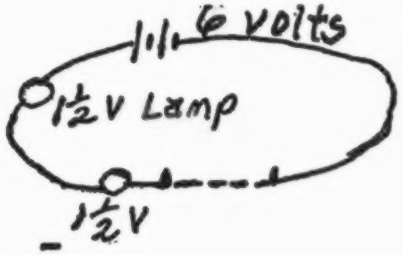
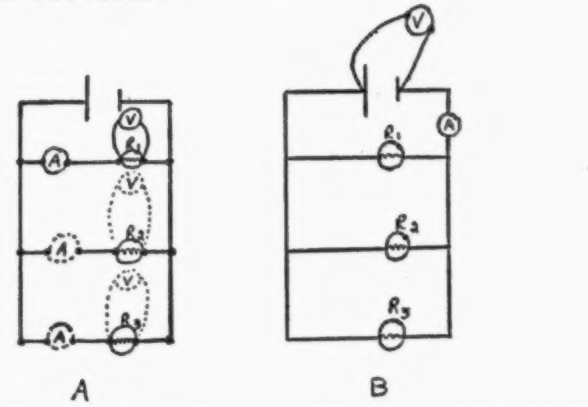
* Reference — "Investigations In Physical Science"; by Warren L. Strickland, Burgess Publishing Company.

Topics	*Understandings*	*Suggested Activities*
E. Ohm's Law	Ohm's Law is best stated in terms of current as follows: The current through a conductor is directly proportional to the potential difference and inversely proportional to the resistance. $A = \frac{V}{O}$ or $I = \frac{E}{R}$	Work problems — Make measurements in parts of circuits and in entire circuits; make calculations. 
	Ohm's Law is applicable to an entire circuit as well as to a portion of the circuit.	Practical electricians sometimes use the above as a "thumb rule". Can you determine how they use it?
F. Series and Parallel Circuits	The effective resistance offered by any number of resistors in parallel is always less than the resistance of the smallest resistor used.	Schematic drawings should be made showing parallel and series connections using some basic electrical symbols.
1. Series	For components connected in series: the same amount of current flows in each component.	Let students assemble series and parallel circuits and make measurements of these quantities.
	The total resistance is sum of all the the resistances of the component parts.	Laws of series and parallel circuits should be discovered by the pupil in a permissive, free inquiry laboratory situation.
	The sum of the voltage drops across each resistor in the circuit equals the voltage of the battery.	 How many lamps should be placed in the circuit?
2. Parallel	The sum of the currents in all component parts of a parallel circuit is equal to the total current flowing through the battery, and potential difference across a parallel circuit is the same or equal to the potential difference across each component part of the parallel circuit.	

Topics	*Understandings*	*Suggested Activities*
		Take the electricians blue print of a school or house and tell which are series and which are parallel circuits. Surprised! Bring cords of Christmas tree lights in series and in parallel and show differences and similarities.
	The reciprocal of the resistances of a parallel circuit is equal to the sum of the reciprocals of the resistances of the components. $\left(\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$	Using voltmeter and ammeter, determine the separate resistances in a circuit. By the same method determine the total effective resistance. Do the measurements support the formula?  To measure each resistance by $R = \frac{E}{I}$ To measure total effective resistance by $R = \frac{E}{I}$
XVII. Electromagnetism A. Producing Magnetic field Electro-magnets	Any moving electric charge is associated with a magnetic field. When the moving electric charge passes through a conductor the magnetic field appears to be around the conductor.	Film: How to Produce Elec. Currents with Magnets (EB) See film list, item 23. Develop an electromagnet. Learn how to increase the strength of the electromagnet. Film: Magnetism Elec. and Gravitational

Topics	*Understandings*	*Suggested Activities*
	The strength of a magnetic field depends upon: voltage; amperage; length of wire in coil; size of wire cross-section; resistivity of the wire.	Fields (EB) See film list, item no. 24. How could the strength of a bar magnet be rebuilt?
B. Production of Elec. Current	Changing a magnetic field of a coil by changing the direction of current through the coil will induce charges to move in a near-by conductor.	Make a simple transformer, measure current and voltage on each side, reverse connection to transformer and measure each side. Increase coils in one side and measure. Discuss transformers at generation plants and near the home.
C. Alternating Current	Charges move back and forth on a conductor rather than in one direction only.	
1. Generator	The free electrons in a conductor which is moved across a magnetic field experience a force due to the changing magnetic field. The resulting motion of the charge constitutes an electric current. The direction of motion of the charge depends on direction in which the conductor moves through the field; if the conductor is moved with circular motion the charges in the conductor will periodically change direction. The principal parts of generators are: magnetic field coils, armature and slip rings or commutator (on D.C. generators.) The armature revolves within a fixed magnetic field in small commercial generators, whereas, in larger generators the magnetic field moves within a fixed armature. Charges move back and forth in a conductor rather than in one direction only.	Many obvious applications of elec. energy may be used. Simple generators may be made.

Topics	*Understandings*	*Suggested Activities*
2. Motor	A current flowing in a conductor which is situated in a magnetic field will cause a conductor to move at right angles to the magnetic field. If the conductors are wound into an armature the resulting motion will be circular.	Make a simple electric motor, identify the parts and tell uses of each part. What would be the results if any part were defective or omitted? Identify devices used in the home which contain electric motors. Note power ratings and other data on the motors.
XVIII. Applications of Electrical Energy		
A. Mechanical Energy	Electrical energy may be used to produce rotational motion in an electric motor, which is a form of mechanical energy. The electric motors may do useful work through a transfer of energy by means of pulleys, belts, gear wheels, etc. A given amount of electrical energy will produce an equivalent amount of mechanical energy if the loss due to friction and heat are not taken into account. The amount of mechanical energy is proportional to product of current, voltage, and time. $ME = \text{amperes} \times \text{volts} \times \text{time}$ $ME = IET$	Activity: Read the wattage rating on the specifications plate on electric motors. How much electrical energy would be used in 30 minutes if it operates at this power? If the motor is 90% efficient, what would be the mechinacal power output? Ask a speaker from local utility company to show how the electrical energy is used to produce mechanical energy, and how mechanical energy is used to produce electrical energy.

CONSTRUCTION OF AN ELECTRIC MOTOR

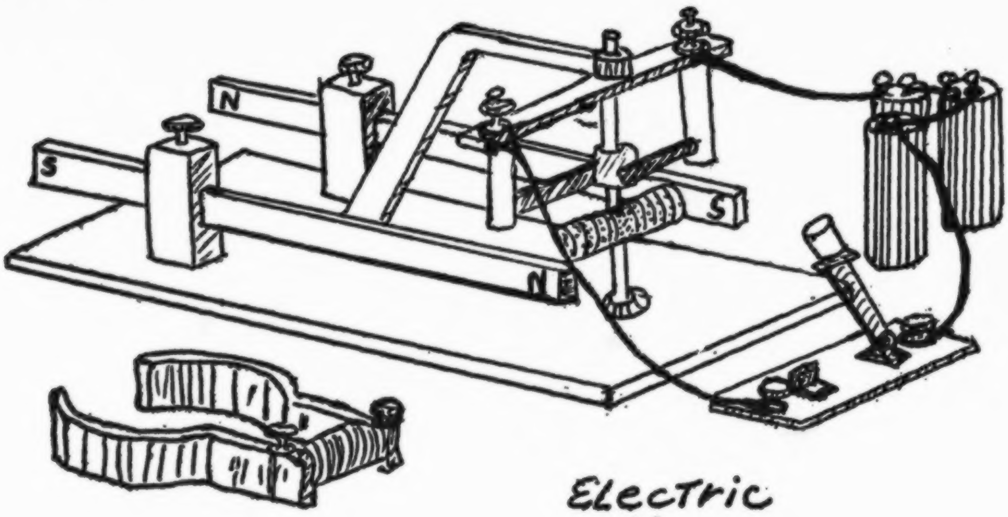
An electric motor is a device used to convert *electrical energy* to *mechanical energy*. This device makes use of some common principles of the electromagnet. The *field coil* and the *armature* are electromagnets. Other parts of an electric motor are the *commutator, brushes,* and *frame*. Notice that the commutator and brushes are a specialized type of switch for changing polarity. If any difficulties arise, consult your instructor.

To construct, operate, and study a simple electric motor.

MATERIALS

5 meters #22 or #24 magnet wire, celloulose tape or plastic electrical tape, small pieces of wooden dowel, or small bore glass tubing, pins, paper clips, thumb tacks, rubber band, copper or aluminum foil for commutator strips, one large U magnet (must be strong), two to four 1½ volt dry cells,, knife switch, plotting magnetic compass.

PROCEDURE



Electric Motor

Measure off 5 meters of No. 22 or 24 magnet wire. Make a fold at the midpoint. Leaving about 5 centimeters for connection, make a coil by winding the wire around the first two fingers until the mid point of the wire is reached. Wind tape around this coil to keep it from unwinding. Wind the rest of the wire into a similar coil and tape it. Tape the two coils to a wooden stock (or glass tubing) as shown, one on each side for balance. Remove the insulation from the ends of the coil for about one inch. Cut two small pieces of copper (or aluminum) foil to serve as commutator sections. Fold one of the coil ends into an S. place one piece of copper over it and tape it to the shaft. Do the same with the other end, making sure that the two pieces of copper do not touch. Put a pin in each end of the shaft. Fashion bearings, using paper clips, so the shaft is mounted horizontally. Adjust it to swing freely and balance the coil, using small pieces of tape. Use two or more paper clips for brushes as shown. Place a U-shaped magnet so that the armature will spin in the magnetic field. Connect two to four dry cells in series and attach them through a knife switch to the brush clips. Sometimes a spin with the fingers is neded to start the motor. The rubber band may be used to hold the brushes lightly against the commutator.

OBSERVATIONS

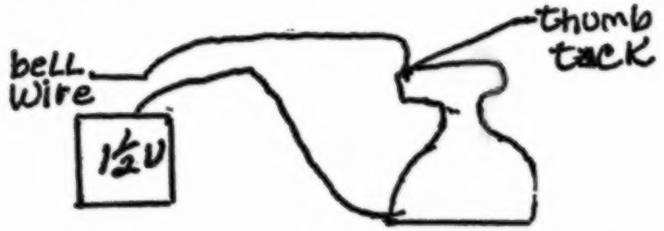
After the motor has been run and is operating in good shape, open the switch. Reverse the U-magnet, pole to pole. Close the switch and observe. Open the switch and reverse the connecting wires on the brush terminals.

Close the switch and observe. With the plotting compass, determine the polarity of the U-magnet and mark the poles with chalk. Remove the magnet. With the plotting compass determine the polarity of the armature coil. Rotate the armature one half turn and again check the polarity of the armature coil. Turn the shaft very slowly and notice the function of the brushes and commutator.

Compare with motor in the diagram.

FURTHER RESEARCH

1. Can you think of some way to measure the speed at whch your motor operates?
2. You might dsmantle a commercal electrc motor and observe how it is the same and different from your simple motor.
3. Is there a way that you could calculate the maximum power that this small motor might develop?

Topics	*Understandings*	*Suggested Activities*
B. Heat from Electrical Energy (Conversion of Electricity into heat)	Heat results from the flow of electrical current through a resistor. Certain commercial heating elements are especially designed for the conversion of electrical energy to heat energy. Heat (Calories) = $.24I^2RT$ where T is in seconds	Conduct class discussions of commercial apparatus found at home and school that converts electircal energy to heat eneregy, i.e., iron, electric range, and water heaters.
	The amount of heat released is proportional to the resistance and to the square of the current and the time of current flow.	Use an old style coil wire toaster to show conversion of electrical energy to heat energy.
	The amount of heat released is inversely proportional to the square of the diameter of the wire and varies with the resistivity of the material.	Run a copper wire from one pole of a 1½v battery to the other pole; let pupils feel the wire—CAUTION . . .
		Demonstrate by using a 1½ volt battery with a completed circuit in which foil from a chewing gum wrapper is a part of the circuit. Set up the demonstration according to the following and show the use and purpose of a fuse. 
		Solve problems pertaining to kilowatt hours of energy consumed by appliances.

Topics	*Understandings*	*Suggested Activities*
C. Conversion of Electricity to Light	Light results when a conductor is heated to high temperature by electrical energy. There are many forms and makes of electric lamps. Some lamps use electrical energy with greater efficiency than others.	Compare the amount of light produced by a lamp when the voltage is reduced by adding a resistor to the circuit. How does this relate to the dimming of stage lightings? Compute the power bill of the lights in your school room if they are operated continuously during school hours for a month. Make a collection of electrical lamps and show in what respects improvements have been made.
D. Chemical Effect of Electric Current-Electrolysis and Electroplating	Electrical energy is used in the electrolysis process to bring about chemical change at the anode and cathode.	Use copper sulfate solution, a penny and nail, a 6 volt battery in plating the nail.
	Electrolysis is an important industrial process. Some applications are: chromium plating for use on autos; electrotype in newspaper printing; plating scientific instruments.	Report on the process of refining aluminum ore. Bring reports on the process of producing fresh water from sea water. Explain the function of a storage battery. Electrolysis of water may be done through conventional equipment (electrolysis apparatus) and addition of small quantity of sulfuric acid to the water. Note volumes of hydrogen and oxygen produced. *Experiment:* 10 Electroplating *Problem:* To electroplate one metal with another *Materials:* Beaker-500 ml. or battery jar, copper sulfate for copper plating, am-

Topics	*Understandings*	*Suggested Activities*
		monium dichromate for chrome plating, nickel sulfate for nickel plating, 2 dry cells 1½ volt or D.C. power supply, wire two 18" lengths), copper strip and zinc strip *Procedure and observations:* Dissolve 10 grams of metal salt in 350 ml. of water. Connect plates to the other end of each wire. Be careful to connect the metal strip to be plated to the negative(-) terminal of the dry cells. Chrome shows best on zinc or copper, nickel best on copper, copper best on zinc. Place plates on solution and leave from 10-20 minutes.
XIX. Sound A. Definition	Sound is energy produced by a vibrating body.	Demonstrate each with common examples: Infrasonic: water waves, see-saw Audiosonic: range of hearing, detect by feeling vibrations Ultrasonic: dog whistle
B. Producing Sound	Any object that will vibrate produces sound which may be infrasonic, audio-sonic, or ultrasonic depending upon the vibrations per second.	Secure an audiometer if possible and determine frequency range or hearing of different persons.
C. Transmitting Media of Sound	Air transmits sound at approximately 1100 feet per second at standard temperature and pressure.	Student Activity: Using different tuning forks, find the length of a wave by the formula $L = v/f$. (L = wave length, v = velocity, (1100 ft/sec.), f = frequency) Student Activity: Use a stretched rubber cord or coiled spring to study the transmissions of wave characteristics.

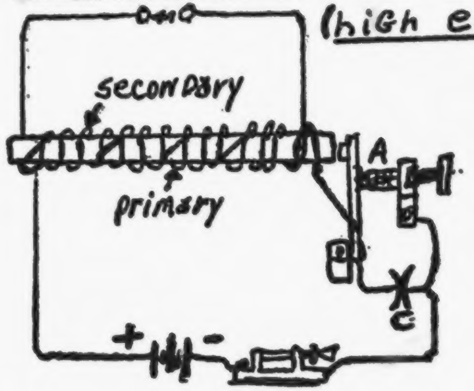
Topics	*Understandings*	*Suggested Activities*
	Usually as the media increases in density, the speed of sound increases.	Student Activity: Make a "string and can" telephone. Listen to sound on: radiator pipe lines railroad track or long wire Attempt to produce sound in a vacuum. Refer to the booklet "Sound Mechanics", available from Bell Telephone.
D. Aspects of Sound	Several aspects of sound are wave length, amplitude, frequency, velocity, intensity, loudness, pitch, and variable frequency. Transverse waves vibrate in a plane at right angles to the direction of the wave motion. Longitudinal waves vibrate in the same direction as the wave motion: A wave may be "modulated" by the interference of one wave with another.	As an aid in presenting the phenomena of waves use a coiled spring. Stretch across the classroom between two students. Start the wave and illustrate wave length, nodes, amplitude, intensity, longitudinal and transverse waves. A super-slinky (coil or spring steel) is also good for demonstrating wave aspects. Water waves can show wave interference and can be observed in a ripple tank or outsidthe classroom. Illustrate longitudinal waves by vibrating weight on a coil spring which is suspended vertically along the axis of the spring. By lightly tapping the axis of the bobbing weight, interference patterns may be illustrated.
E. Acoustics	Sound waves travel in all directions from a vibrating body. The intensity of the sound at any distance from a source follows the inverse-square law	Student Activity: Bring to class acoustical materials for examination by the class.

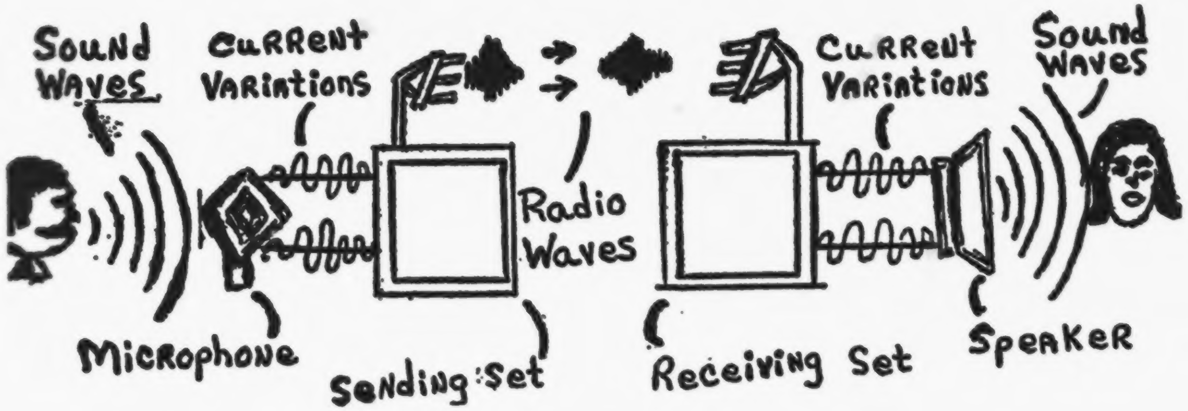
Topics	*Understandings*	*Suggested Activities*
	studied previously.	Students examine sound proof facilities in auditoriums, stadiums, and speaking areas.
	Reflected sound waves can cause undesirable acoustical conditions.	Locate spots in auditorium where sound reception may be poor. Explain. Special report may be made on acoustically designed buildings.
F. Music and Noise	Music results from sound waves that are regular with more uniform amplitude, whereas noise results from irregular vibrations having a variety of amplitudes. When notes are sounded together, the mathematical ratio of the frequencies will determine whether the effect is harmony or discord. If the frequency ratio of two tones is in small whole numbers, they form a pleasing chord.	If an oscilloscope is available notice the difference in patterns produced on the screen when noise or music is made. Listen to sound records available from audio-visual suppliers. The records are designed to show characteristics of sound. Bell Telephone has very good films on this subject. "Music in Motion". See film list, item No. 9. Schedule the band director and/or music teacher to give special demonstration lectures on the sounds of musical instruments.
XX. Light		
A. Definition	The visible light spectrum is an electromagnetic radiation having a wave length between 10^{-4}cm and 10^{-5}cm.	Obtain the film used with the PSSC physics course which tends to illustrate that light exerts pressure.
B. Nature of Light 1. Wave theory	Light travels in waves in a manner which is unique to all forms of radiation.	Report on Huygens Wave Theory and evidences supporting it.
2. Corpuscular theory	It is believed that light exists in unit bundles of energy. (quantum theory)	The following demonstration supports both the wave and corpuscular theory.

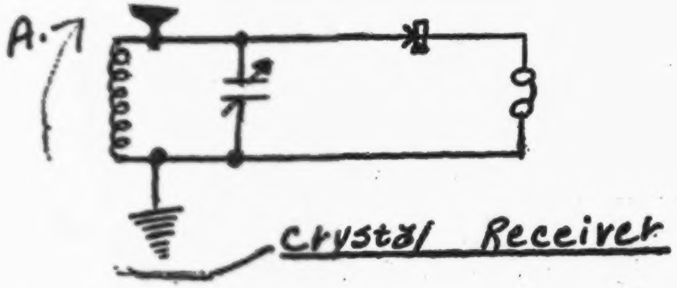
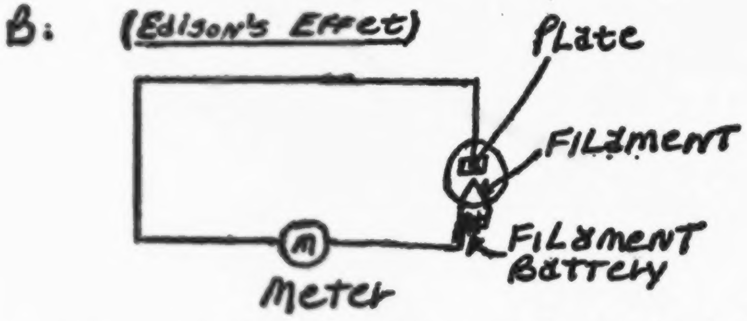
Topics	*Understandings*	*Suggested Activities*
3. Polarized Light	Light waves may travel in horizontal and vertical planes.	Demonstrate the use of polarized lens by looking at an object through a pair of lenses and slowly rotating one of them 90 degrees. Observe that the light is unable to pass through. Demonstrating polarization with the microprojector: Place strips of scotch tape on a slide. Crisscross the tape in every direction. Turn one of the lenses and note beautiful colors, etc. Put a small amount of resorcinol (dissolved in alcohol) or acetamide crystals on a blank slide. Set with the heat of a match. Wipe carbon off the slide and place the slide on the stage. Dirt on the slide or in the crystals will crystallize out. If no crystals appear, touch with a match. You may have to move the slide to see the spears of crystal grow. Graphically illustrate polarization by use of wave motion of a rope through a "picket fence" arrangement.
C. Source	Light is a form of radiant energy which is emitted when an electron moves to a lower orbital, nearer the nucleus, from a higher energy level. Light travels at a constant speed regardless of the speed of its source (relativity).	Recommended problems and experiments illustrating electromagnetic radiations are presented in the filmstrip by that name #612, Filmstrip-of-the-Month| See Ref. No. 82. General Electric publishes bulletins on the laser and maser. Honeywell Corporation, Minneapolis, has materials and film on lasers and masers.

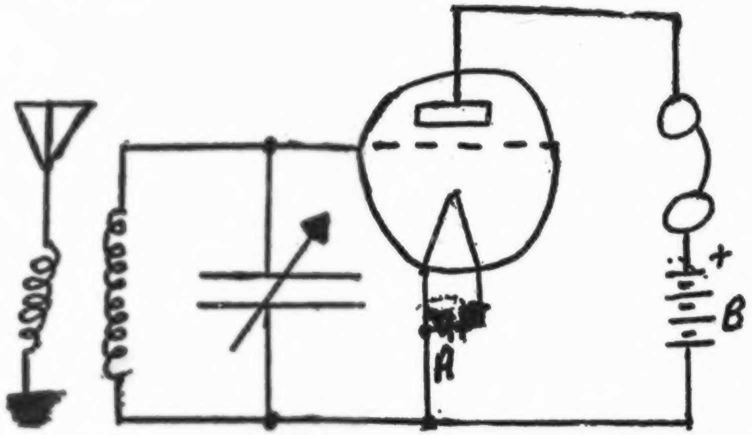
Topics	*Understandings*	*Suggested Activities*
D. Ilumination and Intensity of Light Source	The intensity of illumination of a lighted surface varies inversely as the square of the distance from the light source. This is expressed in foot candles.	Cut a square foot or less in a cardboard, place it one foot from the light source. Place a second cardboard two feet from the source. Compare areas of illumination. How much is the illumination? This is more effective if done in a dark room. A light meter may be used to measure the intensity of illumination.
2. Strength of light at source (luminous intensity)	The strength of light at its source is expressed in candle power which is the light emitted by a standard candle. The relation between foot candles and candle power is expressed by the formula; Foot candles equal $\frac{C.P.}{d^2}$	Find the illumination in foot candles of a lighted surface that is 5' from the light source rated at 100 candle power.
E. Refraction and Reflection	The refraction of light varies with the refracting media. In the case of a plane mirror the image appears to be the same distance behind the mirror as the object is in front, and it appears to be reversed. Concave mirrors are used in large telescopes to produce images and in lamps to produce parallel beams of light (auto headlights).	Graphically illustrate refraction. Demonstrate refraction with different types of lenses and prisms, also other types of transparent substances. Discuss refractive index and its uses. Study the lens of the human eye and explain farsightedness and nearsightedness. Make a telescope using concave mirrors. Make a periscope using plane mirrors.

Topics	*Understandings*	*Suggested Activities*
F. Visible and Near Visible Portions of the Spectrum	The rods and cones of the 7th layer of the retina interpret intensity and color of light. Visible light which man can see is only a small portion of a large electromagnetic spectrum. Infrared rays are heat rays and are longer than visible light rays. Ultraviolet rays are shorter waves than visible light rays.	Draw a straight line 10 inches long on the chalkboard and mark off one inch section near the center to show that portion of the spectrum that is visible light. Take the 1 inch and expand it to approximately 3 feet and sub-divide into color bands showing the wave lengths in inches. Discuss the x-ray and infrared radiations. Assign student projects of photographing animate and inanimate objects with infrared sensitive film. (Note: caution student to use red glass filter on camera.)
G. Invisible Electromagnetic Radiation	At either end of the visible portion of the spectrum electromagnetic waves of light can be detected by special instruments.	Library research should be encouraged on discovery of and uses of radio, radar, cosmic, gamma, and micro waves.
XXI. Radio & Television		
A. Radio	A basic understanding of magnetism and electricity is essential to the understanding of the principles of radio.	Review the basic principles and refer to experiments on electricity and magnetism leading up to radio transmission.
1. Principles 2. Development of instruments 3. Circuits	The gradual development of instruments such as the telegraph, phonograph, wireless telegraphy by different men in science led to the development of the idea and production of radio.	Make a Hertzian coil. Use a radio receiver across the room and produce sparks in coil. Observe what happens in radio receiver. (Science for a Better World.)
	From previous understanding the pupils should know that in an induction coil, a variable current flowing in one coil produces or induces a varying current in a nearby coil circuit.	Illustrate a simple radio circuit in broadcasting and receiving stations.

Topics	*Understandings*	*Activities*
Radio (continued)		Examine induction coils. Make an induction coil. (high emF)  secondary primary A C + -
4. How it works	How it works:	

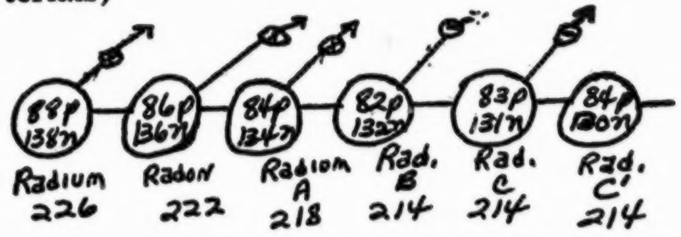

Sound Waves
Current Variations
Microphone
Sending Set
Radio Waves
Receiving Set
Current Variations
Sound Waves
Speaker

Topics	*Understandings*	*Activities*
5. From crystal to vacuum tube	Historic Discoveries in Development of Radio:  A. Crystal Receiver  B: (Edison's Effect) Plate FILAMENT FILAMENT BATTERY Meter	Make a field trip to a local radio station, radio shop or telephone office to see the workings of these installations.
	As currents flow through a conductor, heat is produced. A heated filament discharges electrons into the surrounding areas. C. Fleming used the Edison tube as a detector. D. DeForest's Grid Tube—used as both a detector and an amplifier. See grid tube on next page.	Take an old radio tube and identify the parts. Illustrate and explain use of each part.

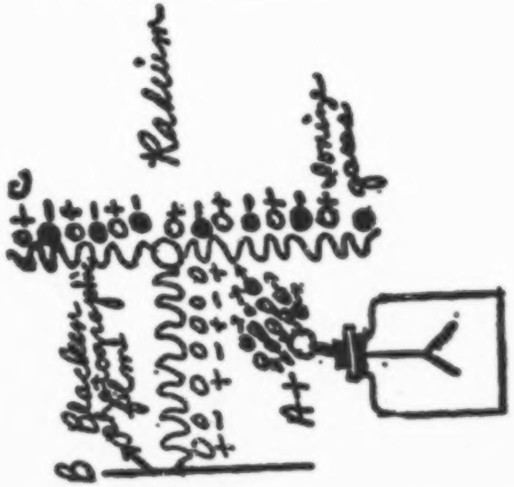
Topics	*Understandings*	*Activities*
A. Radio (continued)		
6. Waves	Maxwell, through mathematical calculations, predicted radio waves and a relationship between light and electromagnetism.	Make a list of all the men who have aided in understanding radio. Make oral reports on contributors to radio and their methods of scientific investigation.
	These predictions were confirmed by several men in various experiments including Hertz, Marconi, Edison, Fleming, J. J. Thompson, Lee DeForest, and others. Each added a new device or devices which led to the radio.	Others reports could be made on the changes which have been brought about in our modern world by the invention and development of radio.
	A method of producing radio waves was found in the vacuum tube which contains the filament grid, plate, and is surrounded by a glass tube.	
	The grid circuit becomes the center of an electrical disturbance from which travels a radio wave in all directions.	

Topics	*Understandings*	*Activities*
	These radio waves may be made to carry voice and then are called modulated waves. When modulation is accomplished by varying strength of the wave, it is called amplitude modulation.	Dissassemble an old radio. Reassemble parts into groups of coils, capacitors, resistors, tubes, and connecting parts. Mount on a board.
	Radio waves may be used in "radio detection and ranging" called radar. In radar transmission the radio wave itself is the result of a surging to and fro of electrons. To free radio from static, radio engineers developed frequency modulation.	Characteristics of a triode tube may be shown. a. Set the grid voltage at about minus 3 volts and demonstrate the effect of plate voltage on plate current. Take corresponding readings of plate volts and plate current and plot on a graph. b. Set the plate voltage at maximum and vary grid voltage. Plot plate current on a graph against grid voltage.
7. Vacuum tubes and transistors	The transistor, by use of germanium metal, has been substituted for the vacuum tube.	Note — The base of a triode tube may be mounted on a board in preparation for this demonstration. Visit a radio installation or have radar engineer to visit the school and learn the many uses of radar for peacetime purposes.
B. T.V.	Pictures or scenes can be described by a set of electrical signals, which consist of electric currents produced by radio waves that fluctuate in accordance with the signals sent. Our eyes respond to different amounts of light which come from different parts of a picture or scene.	Study the uses of photoelectric cells in our modern life. Make reports on as many uses as possible. Make a simple photoelectric cell. The directions may be found in many popular science books. Visit a T.V. station and learn all that you can about transmission and reception.

Topics	*Understandings*	*Activities*
	The points of a picture may be signaled by telegraph, telephone, or by reflected beams of light. The net result is transmission of a picture across space.	
	A photoelectric cell is a device used to change light impulses into a varying electric current. By using a scanning device the photoelectric cell "sees" separately each point of a scene.	Make reports on works of Zworykin and Farnsworth on how TV was developed. Find out how teletypewriter works and how telephotos are sent. Make a simple model of a cathode ray tube which is similar to the kinescope tube. A physics student may be asked to demonstrate an oscilloscope and relate an oscilloscope to a TV receiver.
2. Iconoscopic tube	Modern television transmitters use an iconscope tube, which is a combination of an electron camera and the eye in principle. (Heart of iconoscope is image plate or Mosaic plate.)	
3. Kinescope tube	Varying currents are broadcasted and received in radio sets. These radio waves are changed back again into the original picture or scene in a receiving set called a kinescope.	
	An electron gun fires an electric beam which strikes the flat end of the tube. This is synchronized with the scanning in the iconoscope. The electron beam is pulled back and forth by electromagnets outside the tube.	

Topics	*Understandings*	*Activities*
4. Color transmission	In color transmission it is possible to separate colored objects by filters, and these impulses fall in sequence upon mosaic plates in the camera tube. These are broadcast. In the receiver these colors pass through similar filters which relay these to the eye. Other methods of color transmission have been used. Film: "Electromagnetic Waves" Modern Learning Aids "Franch-Hertz Experiments" — Modern Learning Aids	
XXI. Nuclear Science A. Nuclear particles and radioactivity	The nuclei of heavy atoms contain more than 30 known particles. Certain atoms emit these particles in the form of radiation. Alpha, beta, and gamma rays are given off naturally. Alpha particles are positive and beta particles are negative. The alpha particle is essentially a helium nucleus. $_{88}Ra^{226} \rightarrow {}_{2}He^{4}$ (Helium) $+ {}_{86}Rh^{222}$ The beta particle is an electron of nuclear origin. $_{0}N^{1} \rightarrow {}_{1}P^{1} + {}_{-1}e^{0}$ $_{6}C^{14} \rightarrow {}_{7}N^{14} + {}_{-1}e^{0}$	Graphically show what materials will protect from each form of radiation. Consult your Civil Defense office for information. From Abbott Lab, Oak Ridge, Tennessee, obtain some radioactive elements to be used in demonstrating detection with Geiger counter (no license necessary to obtain materials)  88p 138n 86p 136n 84p 134n 82p 132n 83p 131n 84p 130n Radium 226 Radon 222 Radium A 218 Rad. B 214 Rad. C 214 Rad. C' 214 THE DECAY OF RADIUM—Starting with radium, an atom changes again and again,

Topics	Understandings	Activities
	Gamma rays are electromagnetic radiations of pure energy.	giving out either alpha particles (helium ions) or beta particles (electrons).
		Build a Geiger counter from directions given in materials available from American Petroleum Institute.
		Teacher Demonstration: Cloud Chamber using a pound coffee can (low can) cut a hole out in the lid and cover with Seran wrap. Cut a window about 3" x 2" in the side of the can. With masking tape make a tight fit of Seran wrap over the window. Cover the inside of the can with black blotting paper. (Construction paper will do but do not cover the window).
		With a good grade of methyl alcohol put ¼" in the bottom of the can. Color the alcohol black with Indian ink. Get a cake of dry ice 2" x 8" x 8".
		Place the dry ice in a pan with newspapers in and around the ice for insulation. Keep the pan and the ice level. Place the can on top of the ice. Be sure the lid is secure on the can. Hold a good strong source of radiation up to the window. (If radiation source can be taped across the window with scotch tape, do so.) With a strong source of light passing through the window, look straight down into the can. (The alcohol vaporizes; as it cools you have alcohol rain which falls. The tracks are curvy lines of the concentration of these droplets of alcohol rain.) If

Topics	*Understandings*	*Suggested Activities*
Nuclear Particles and Radioactivity (continued)		the lines are straight and thick, they are alpha particles. If they are crooked, fuzzy and very short, they are beta particles. These lines are not the particles themselves but the tracks they make. Charge an electroscope with a bakelite rod. Hold near a wrist watch with radioactive dial and break the charge.  Rays from Radium (A) Ionize Air and Discharge the Electroscope. (B) Blacken the Photographic Film. (C) Make the Crystal Fluoresce, or Give "Cold Light."
B. Isotopes	Atoms of the same element which have the same chemical properties but different atomic weights are called isotopes. This dif-	Film: "The Strange Case of the Cosmic Rays . . ." Bell Telephone. See film list, item no. 13.

Topics	*Understandings*	*Suggested Activities*
	ference occurs due to a differing number of neutrons. Some isotopes are radioactive and this property is used in research.	Discuss how isotopes are used as tracers in industry, medicine, and agriculture. Class project: Using radioactive material (P^{32}), develop the project on tracers along these lines. Obtain X-ray film from your local hospital. Obtain a table of the isotopes from General Electric free. Grow previously or obtain small tomato plants. Add the 6^{32} to 250 ml of water which has been made slightly (acidic) with nitric acid. (This helps in diffusion.) Count out 6 tomato plants of the same size. Place all the plants into the solution at one time. At intervals of 30 minutes, remove a plant. Press the plant in Seran wrap and in the dark room place the X-ray film over the plant. Place the film and the plant in a black folder which has been previously labelled with a number and the length of time in solution. Lay this folder aside weighted with books. Continue to remove plants at 30 minute intervals and follow the same procedure for each. Leave the films exposed to the plants for 4 or 5 days. Have the film developed according to procedure for X-ray film. There is no danger in using this radioactive material. Use the precautionary measure for X-ray film that you would with ordinary film. Observe the results of the movement of the isotope into the plant. Bring to mind and apply the many uses and applications of the results of the project.

Topics	*Understandings*	*Suggested Activities*
C. The Release of Nuclear Energy 1. Terminology a. Fission	Fission is the process of splitting the atom into smaller particles. Transmutation is the process of changing the elements into new elements. Critical mass is the amount of material giving off emanations sufficient to cause a continuous reaction. The "breeder" reactor is a device which produces additional fissionable material.	Make a simple chain reaction with matches. (Matches lighting other matches.) Explain by diagram the operation of a "breeder" reactor and how it works. The idea of critical mass may be demonstrated by drawing a ring and placing only a few marbles in the ring. Observe number of marbles set in motion when one marble is fired into the ring. Repeat this using a great number of marbles in the ring.
	Accelerator: A device which is used to increase velocity of atomic particles used in atomic research. Mass spectograph and a gaseous diffusion process are methods of separating isotopes.	Film: "Atomic Energy Series" (EB) See film list, item No. 25. Build a model using the principle of the cyclotron with an outward spiral moving downward in a cone. Use a marble as the accelerated particle to demonstrate increase of velocity.

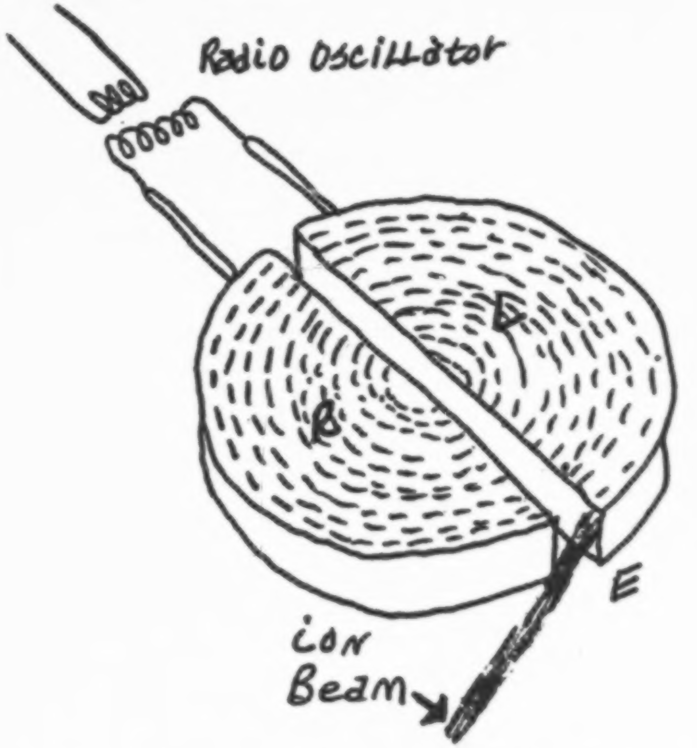
Topics

Understandings

How a Cyclotron Works—Hyrodgen ions (protons) are driven around and around, faster and faster. A magnetic field that is perpendicular to the path of the ions keeps them moving in circles. Finally, they escape at E.

The nuclear reactor (atomic furnace, atomic pile), is a device which is used to regulate the rate of fission and may be used to produce heat as well as isotopes, thus leading to many industrial uses.

Suggested Activities



Invite a specialist to visit and discuss progress being made in use of radio-activity. (Consider university and college centers, medical research, and industrial research.

Collect materials from news articles, industrial reports and scientific journals.

Study the structure of a typical nuclear reactor and show by the drawings how the heat produced here may be used to operate

Topics

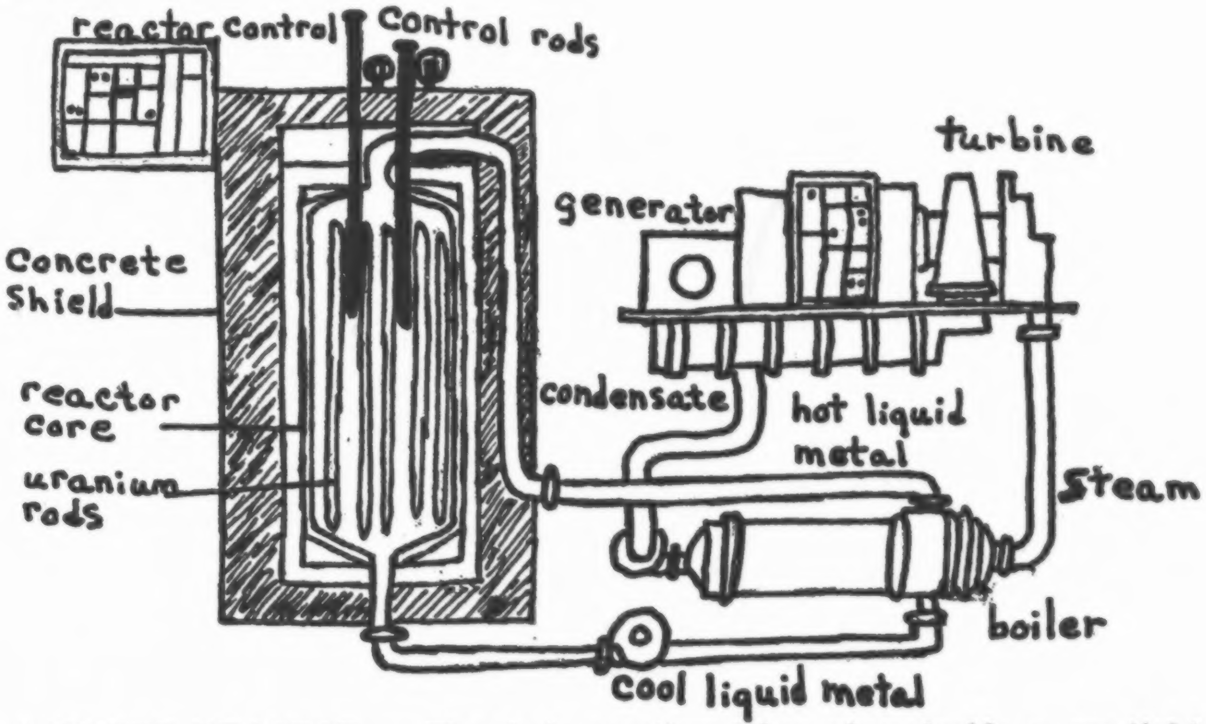
Understandings

Make charts showing isotopic forms and their uses.

Graphs may be constructed to show the relationships between nuclear power plants and steam generating plants such as efficiency, cost and fuels used.

Suggested Activities

machines or steam generators. Indicate areas where special shielding would be needed. Make a model as a result of this.


reactor control
Control rods
turbine
generator
Concrete Shield
condensate
hot liquid metal
reactor core
uranium rods
Steam
boiler
cool liquid metal

A POWER REACTOR — The chain reaction takes place inside a gas-tight tank. Water inside the reactor slows down neutrons and also carries away the heat produced. In the heat-exchanger, the 'superhot' radioactive water from the reactor changes non-radioactive water from outside the reactor into steam. The steam turns the turbogenerator, and electrical energy is sent out.

Topics	*Understandings*	*Suggested Activities*
	MEV — (Million Electron Volt) is the unit used to measure the amount of energy produced when mass is converted into energy. 1 mass unit = 931 MEV.	
b. Fusion	Fusion — Fusion is the process of combination of two light weight nuclei to form a heavier, more stable nucleus.	Film: "Our Mr. Sun" (Bell Telephone Company) See film list, item No. 15. Models of some atoms which have been altered by fusion could be made and then altered in similar manner. Discuss the increase of energy in fusion explosions in comparison with fission explosions and limits of control for peaceful uses.
2. Instruments related to radioactivity	Many devices have varying uses related to understanding of radioactivity. These include: Geiger counter Electroscope Dosimeter Scintillation Counter Cloud Chamber	Ask local C. D. officials to bring examples of these instruments to the school to demonstrate their uses and to allow students to read and calibrate. Consult the local physicians or hospitals for information on use of radioactivity in medicine.
D. Peacetime Applications of Nuclear Energy	There have been many recent applications of nuclear energy in these fields: Industry, agriculture, medicine, space exploration, research.	Develop a field trip to one of the Miss. Agricultural Experiment Stations (widely scattered over the state) to learn what is being done with isotopes in their area in agricultural reasearch. See Reference (a.)

References:

(a.) *Guide for Teaching Science.* State Dept. of Education Columbia, South Carolina (Grades 7-12) 1962 Edition.

Topics	*Understandings*	*Suggested Activities*
XXII. Career Opportunities A. Manpower	The welfare, security, and economic growth of the nation depends upon a supply of scientists, engineers, and technologists.	Develop discussions along these lines to support these understandings: How does the security and welfare of our nation depend upon our supply of scientists?
B. Literacy	The welfare and security of the individual as well as society depend upon the scientific literacy of the general public.	If you do or do not have flouridation in your city water systems, what community problems were solved or must be solved before the step was or is made possible?
C. Leadership	The rapid acceleration of advancements in science and technology in a democracy brings even closer the need for trained scientists in positions of leadership.	Develop a panel discussion on how decisions of our civic leaders are more and more dependent upon their technical knowledge. Discuss: The roles of particular scientists, local opportunities for technically trained personnel. Career guides: Pollack, Philip. *Careers and Opportunities in Science: A Survey of All Fields.* Dutton, 1960. 194 pp. illus. Pollack, Philip. *Careers and Opportunities in Physics.* Dutton, 1961. 159 pp. illus. Esterer, Arnuf. *Your Career in Chemistry.* Messner, 1964, 190 pp. illus. Nourse, Alan E. *So You Want To Be a Doctor.* Harper, 1963. 173 pp. Carroll, John M. *Careers and Opportunities in Electronics.* Dutton, 1963. 191 pp. illus. Greenberg, Saul N. and Joan R. *So You Want To Be A Dentist.* Harper, 1963, 168 pp. Pollack, Philip. *Careers and Opportunities in Engineering,* Dutton, 1959. 140 pp. illus.

HANDBOOK SECTION — PART IV

Expermiments, Demonstrations and Extended Activities

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    (1) The Siphons
    (2) Rate of Flow of Siphons
    (3) The Candle and Jar
    (4) Radiobiology
    (5) Effect of Temperature on Bacterial Growth
    (6) Inhibition of Bacterial Growth
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    (8) Inheritance of Taste Ability
Demonstrations (106 different demonstrations) Page 308-317
(See index to demonstrations.)

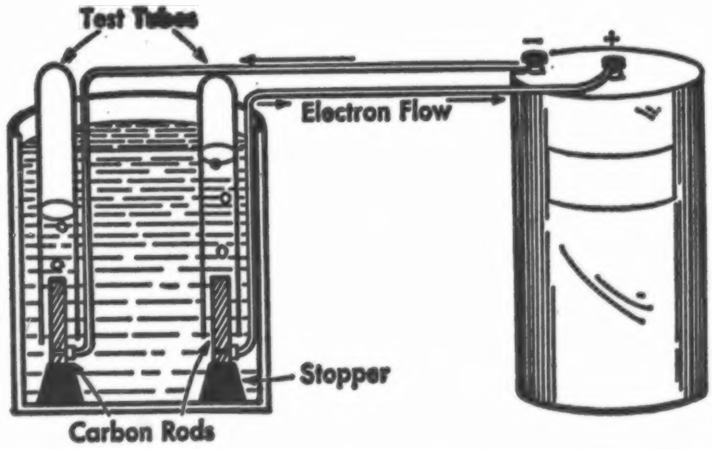
ELECTROLYSIS

Electrolysis is decomposition by means of electrical energy.

Decomposition of some compounds may be accomplished by means of heat. For example, Priestley, in 1774, decomposed mercuric oxide, using a lens to focus the sun's rays on the red powder, according to the equation below.

$$\underset{\text{(red powder)}}{2\,HgO} \xrightarrow{\Delta} 2Hg + O_2 \uparrow$$

This method proves ineffective with a compound such as water. Heating water would serve only to convert it to the vapor state. Decomposition of water is possible, using an electric current. The equipment is shown in the diagram below.



Direct current electricity is passed through the water. Oxygen gas O_2 collects at the positive terminal, hydrogen (H_2) gas at the negative. A small quantity of *dilute* sulfuric acid is added to make the water a better conductor of electricity.

$$2\,H_20 \xrightarrow{\text{elect.}} 2\,H_2 \quad + 0_2 \uparrow$$

This method of decomposing water is a good industrial water preparation of both gases, oxygen and hydrogen. The raw material for the process is cheap and easy to obtain. Electricity, the power needed, is also relatively inexpensive. These conditions are necessary for the success of any industrial process.

If the reaction is allowed to continue until one test tube is filled with gas (H_2), the other test tube (containing 0_2) will be half full. Simple tests for these gases (a glowing splint for 0_2, careful igniton of the hydrogen) may be conducted. It can thus be shown that the volume ratio of the two gases produced from the decomposition of H_20 is $\underset{\text{(hydrogen)}}{2} : \underset{\text{(oxygen)}}{1}$.

Examination of the test tube after igniton of the hydrogen will show a few drops of H_20.

$$2\,H_2 + 0_2 \xrightarrow{\text{(ignition)}} 2H_20$$

QUANTITATIVE PREPARATION OF OXYGEN

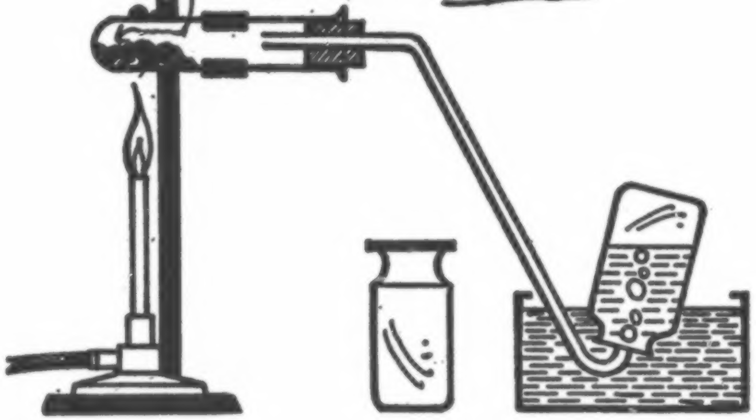
The quantitative preparation of oxygen affords many opportunities for desirable learning activities in keeping with the stated objectives of junior high school science at the ninth grade level. It is suggested that the work be done in the form of a cooperative enterprise, neither as a teacher-conducted demonstration nor as an individually performed laboratory procedure. Division of the class into small groups, each group having the responsibility for a given phase of the work, can be quite effective.

Topics

Preparation of an *element*[1] from a *compound* containing this element

$$2KClO_3 \xrightarrow[MnO_2]{\Delta} 3O_2 \uparrow + 2KCl$$

→ air space important



Understandings

How much O_2 can be made from the *thermal decomposition* of a given amount of $KClO_3$, using MnO_2 as a *catalyst?* Does the use of the *catalyst* really help?

Can the $Mn0_2$ be recovered, thus proving it to be a catalyst?

What is the nature of the *by-product* of this reaction? How *much* can be obtained *theoretically?*

How much is obtained *experimentally?*

Why can the gas be collected by *water displacement?*

Properties of O_2, methods of collecting gases

(Use some of the oxygen collected in a study of the properties of O_2.)

Suggested Activities

Refer to any elementary chemistry manual for details of procedures needed to prepare oxygen. [2]

Weigh empty test tube. Add $KClO_3$ and MnO_2 and weigh again. When all the O_2 has evolved, weigh the test tube and its contents.

Determine by subtraction the amount of oxygen prepared.

$Mn0_2$ is fairly insoluble, KCl very soluble, so much of the $Mn0_2$ can be recovered by *filtration.* Evaporate water from solution remaining, thus recovering the KCl (which can be then weighed.)

Heat a sample of $KClO_3$ (without adding $Mn0_2$) to observe the effect of the catalyst.

---

[1] Italic words and phrases are terms which should be discussed as to meaning and use.

[2] CAUTION! *Do not remove from under the test tube without first loosening the stopper. Why?*

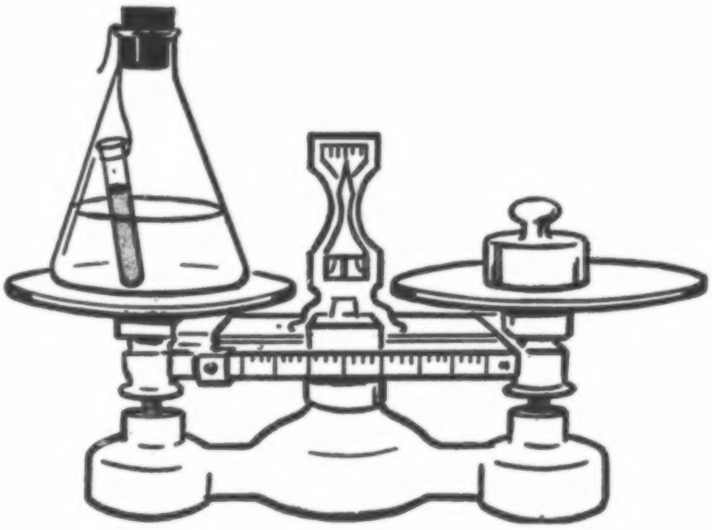
The Chemical Nature of Matter

Scientists are interested in matter and energy. Every chemical change is accompanied by an energy change. Is there a loss, gain, or no change in the amount of matter present as a result of a chemical reaction? This experiment will help to answer the previous question.

1. Pour 50 ml of water into an Erlenmeyer flask. To the water add 5 grams of barium chloride. Pour a small quantity of silver nitrate solution in a test tube and lower this tube into the flask without spilling any. Stopper the flask as shown in the accompanying diagram. Weigh and then carefully tip the flask upside down so that the silver nitrate mixes with the barium chloride solution. What do you observe? Is there physical or chemical change? The complete and balanced equation should read:

$2AgNO_3 + BaCl_2 \rightarrow Ba\ (NO_3)_2 + 2AgCl$.

2. Weigh the flask after the chemical change to see if there is a change in the amount of matter present.



A Study of the Development of Modern Acid-Base Theory

Use the historical approach, beginning with the earliest use of the term acid. (Perhaps the first acid known to man was acetic acid, found in vinegar.) Boyle, Lavoisier, Davy, and others had their own ideas as to what constituted an acid. Throughout the years the term acid has meant many things to many people. Today, one has to specify what kind of acid he is talking about when he uses the term. It is an Arrhenuis acid, a Brönsted acid, et cetra?

Any good history of chemistry will provide material for the beginning study of this topic, which can then be developed into a *long range, library research* endeavor.

If this subject is pursued by the group as a whole, perhaps some class time should be devoted to the development of an outline. If it is to be done on an individual basis, for extra credit, the student should be encouraged to develop his own outline, which could be submitted to the teacher for approval before the writing of the paper actually begins.

Heat and Temperature

Perform this experiment to learn the difference between heat and temperature. Fill one beaker (A) with 50 ml of water, and another beaker (B), of equal size, with 200 ml of water. Take the temperature of the water. Place each beaker on a tripod over a Bunsen burner, keeping the flames of the burners as alike as possible. Take the temperature of the water every minute for 4 minutes and record it in a chart.

Plot your results on a graph, using a red pencil to record the data for beaker A, and a blue pencil for the data of beaker B.

Compare the amount of heat added to each quantity of water. What happened to the temperature of each beaker? What is the difference between temperature and heat? (Temperature measures the average activity of the molecules. Heat measures the average activity also, but takes into account the total number of molecules being heated.)

Collections

Collecting merely for the sake of piling things in a heap is far from scientific, but collecting can be an activity conducive to learning. If objects collected are studied, classified, and appropriately displayed, the collection will prove helpful.

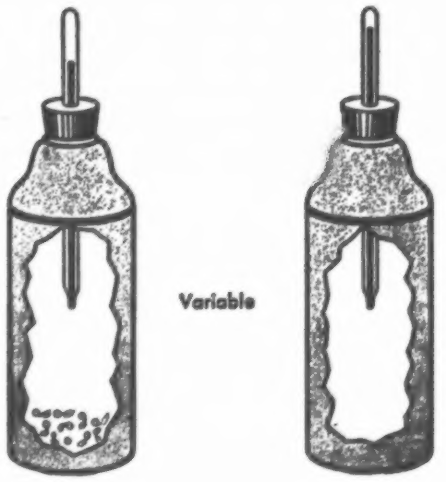
Students should be encouraged to make collections on an individual basis and as a contribution to a group enterprise.

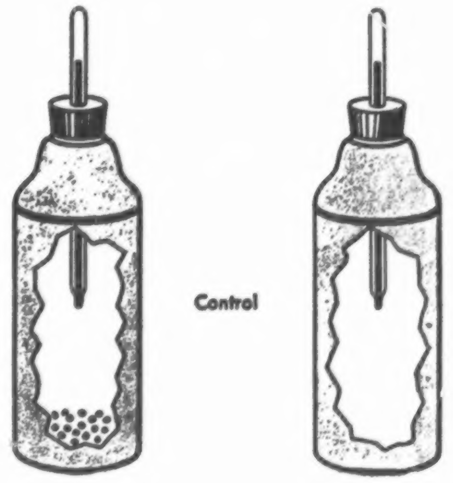
Heat Energy Produced by Plant Respiration

Germinate a cupful of beans, peas, corn, or other seeds. When they have begun to grow put them into a small Thermos bottle. Fit a laboratory thermometer into the hole of a one-hole stopper and place the stopper into the Thermos. Record the temperature at the beginning of the experiment, and again the following day. How has it changed? Continue the experiment for another 24 hours and again record the change in temperature. How do you explain it?

Control the experiment by placing dry seeds in a second Thermos and inserting a thermometer as before.

What do the results of the experiment indicate?





Open End Experiment

Regeneration in Planaria

Find some planarians by examining underwater logs in ponds or lakes. When you have found a log with worms, bring it onto shore or into the laboratory (keeping it moist) and submerge in a pan of water. Strip off the pieces of wood and the worms will usually come to the surface and you can collect them in bottles. Note: you can also attract planarians by putting down a bit of meat tied to a string.

When ready to cut the planarians you will find they are easier to handle if you add a few teaspoons of 1% Epsom salt solution to a collecting jar. Then place one of the anesthetized animals into a drop of water on a microscope slide. Cut the planarian across the middle with a sharp razor. Put each part into a separate petri dish of aquarium water and keep covered in a dark place. Change the water frequently. How soon do you observe changes? What happens to the tail part of the animal?

If you wish to keep planarians for a longer time place them in jars that have been coated with black paint, or in opaque bowls. Change the water frequently, adding aquarium water when you do so. Feed the worms pieces of hard-boiled egg yolk and finely chopped meat, such as beef liver about once a week. Remove excess food to keep the water clean.

This might be carried on as an open end experiment testing environment, and other variables on the growth of planaria.

Extended Experiment

Endocrine Glands and Hormones

This experiment may be conducted to help see that growth regulators are chemicals. Collect 30 tadpoles of about the same age that have just begun to develop legs. Place 15 tadpoles in one jar, A, containing one liter of pond water. Place the remaining 15 in a second jar, B, containing two liters of pond water. Prepare a solution of 10 milligrams of thyroxin dissolved in 5 milliliters of 1% sodium hydroxide. To this, add water until the volume of the solution reaches one liter. (This solution you will add to jar A only.) Add 25 milliliters of this solution to jar A, then add pond water until the volume of the liquid in the jar equals 2 liters. Keep a record of the development of the tadpoles. Notice any difference between the tadpoles in the two jars. Each day place a lettuce leaf on the surface of the liquid in each jar to serve as food for the animals. Be sure to remove the uneaten parts at the end of each day. Change the water if it gets cloudy remembering to repeat the addition of the chemical. (The tadpoles in Jar A would metamorphose more rapidly than those in jar B but would not grow as large.) Other experiments using other chemicals may be tried. Other animals may be substituted for the tadpoles.

DETAILED STUDY OF A SPECIFIC AREA

This may be a small area of one's yard, a small section of the school ground, or a wooded section. The choice is almost unlimited.

The study should include:

1—a map of the area (drawn to scale)

5

2—soil samples
    (a) taken at different depths
    (b) tested for acidity, organic content, organisms, etc.
    (c) classified as to type

3—plant life
    (a) classified (phyla,—species, variety)
    (b) displayed in poster form if possible
    (c) evaluated (economic, scenic)

4—animal life (if any)
    (a) birds
    (b) insects

5—rainfall
    (a) drainage
    (b) water content of the soil
    (c) erosion

6—time limitations (to be set by teacher and class)

7—records of observations
    (a) notebook
    (b) periodic

Laboratory Report

Early in the study of science a student should learn how to write a report on a laboratory exercise, project, or experiment.

The following sample illustrates a form of writing which is acceptable. *Technical Writing* is a separate and distinct course, which the science student will encounter in college or industry. The form below is a modified version of that recommended by the authors of textbooks on technical writing.

Note the divisions (problem, purpose, discussion, diagram, materials, procedure, data, calculations, solution to problem).

The *personal pronoun* is *not* used. Instead, the verb form is *past tense, passive voice.*

LABORATORY REPORT—(SAMPLE)

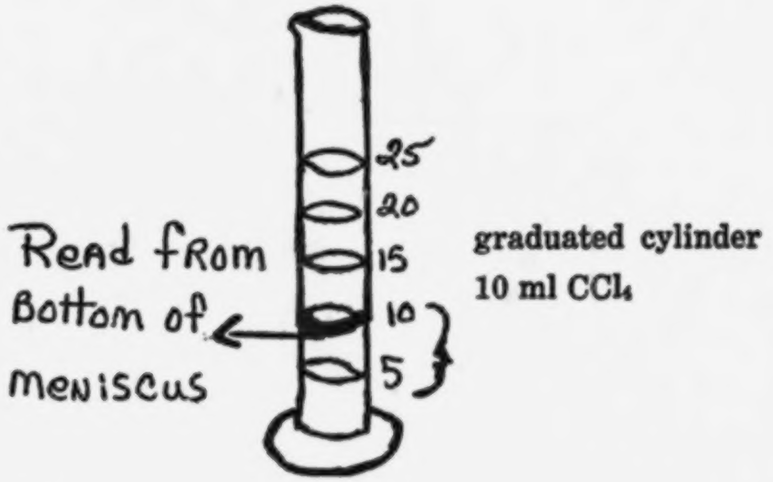
PROBLEM: What is the density of carbon tetrachloride?

PURPOSE: The purpose of this laboratory exercise is to find experimentally the density of a liquid, $CCl4$.

DISCUSSION: The density of a liquid may be determined by weighing a known volume of the liquid and then using the density formula, $D = W/V$.

Error may be determined by comparing the experimental value of the density to the value as given in the literature. See calculations.

DIAGRAM:



MATERIALS: graduated cylinder
carbon tetrachloride
balances

PROCEDURE: A graduated cylinder was cleaned, dried, and weighed.
Ten ml of CCl_4 was added to the graduated cylinder. The cylinder and its contents were weighed.

DATA:

Weight of graduated cylinder + 10 ml CCl_4	39.8	gm
" " empty graduated cylinder	24.4	gm
" " 10 ml CCl_4	15.4	gm

CALCULATIONS: Density $= \frac{\text{Weight}}{\text{Volume}}$

$$D = \frac{15.4 \text{ gm}}{10 \text{ ml}}$$

Experimental value of density: $D = 1.54$ gm/ml

LITERATURE VALUE (FROM HANDBOOK): Density of $CCl_4 = 1.60$

Experimental value $= 1.54$

$$\begin{array}{ll} \textit{Error} & \overline{0.06} \end{array}$$

$$\% \text{ error} = \frac{\text{amount error}}{\text{literature value}} \times 100$$

$$= \frac{0.06}{1.6} \times 100$$

$$= 0.04 \times 100$$

$$= 4\%$$

PROBLEM SOLUTION: The density of CCl_4 was found to be 1.54 gm/ml.

AN EXPERIMENTAL ACTIVITY ON FORCE AND HORIZONTAL LINEAR MOTION

A frictionless cart, well-oiled ball-bearing roller skate, or a dry-ice puck can be used to demonstrate many properties of motion, such as inertia of motion, force, friction, velocity, acceleration, and the effect of mass. The puck must be used on a glass surface which is absolutely level. Such a surface is also best for the cart. The skate may be too heavy and hard for use on glass.

Strobe photographs, using either standard camera with a time or bulb shutter setting, can be taken. These photographs provide visual records of the actual experiment and a means of determining time factors from the motor speed of the stroboscope in rpm. (Simply divide by 60.)

Using ½" paper tape with a bell timer clapping against carbon paper underneath the tape also gives a visual record. In conjunction with the stroboscope and camera a picture of the experimental device can be taken as it moves along the path of motion. A meter stick in the background, horizontal to the table surface, will indicate the distance traveled. A slender pointer mounted on top of the experimental device is useful in measuring the distances accurately.

When the more sophisticated timing devices are not available, a stop watch serves nicely.

Directions for making the apparatus described above may be found in Figures 1, 2, 3, and 4.

ACTIVITY Force-Mass-Inertia Measurements.

Principles.

(1) The inertia of rest can be overcome by a force.

(2) An object, when set in motion by a force, wil tend to continue in motion.

(3) The time which an object will travel is directly proportional to the force, if the mass is held constant.

(4) The distance which an object will travel is directly proportional to force, if the mass is held constant.

(5) The time which an object will travel is inversely proportional to an increase in mass, if the force is constant.

(6) The distance which an object will travel is inversely proportional to an increase in mass, if the force is constant.

Variations in force for linear motion may be had and controlled to some degree by the use of the sling-shot principle. A heavy rubber band or strong elastic stretched loosely between two ring stands clamped to either side of a table (at least 2 feet from the end) with C-clamps will provide the force. Mark a line where the band reaches across the table. Tape a meter stick from the line to the end of the table for measuring force (by inference.) By tying a string to the cart or other vehicle, it can be pulled back selected distances, then cut to allow the force to act.

(1) Weigh the cart and give it a small push with the rubber band and record the results with the strobe or timer. Record the weight, time, and distance traveled. Then repeat the experiment by adding increased

measured force on the cart. Keep the weight constant for each trial. (The dry-ice puck is not usable without adaptation for adding weights.) Record the data for each trial on a table.

a. Graph the data for force and time. Draw conclusions from the graph. What is the effect of force on time traveled?

b. Graph the data for force and distance traveled? What is the effect of force on distance?

(2) Select a measured force for the cart, and repeat the experiment, varying the amount of mass with each trial. Table and graph the data. What is the effect of mass on time, on distance traveled?

Extended Activities.—A principle which holds true for one quantity (of mass, time, or distance) will hold true for proportionate quantities.

Repeat each of the experiments for various forces and masses. Table and graph the data for each set of experiments. Draw conclusions for each set of experiments. Compare the results of the various sets of experiments for a variable of force, for a variable of mass.

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[1] Film Strip of the Month Clubs, "Laws of Motion", Teaching Guide for Filmstrips No. 608, New York: Popular Science Publishing Co., Inc., 1961.

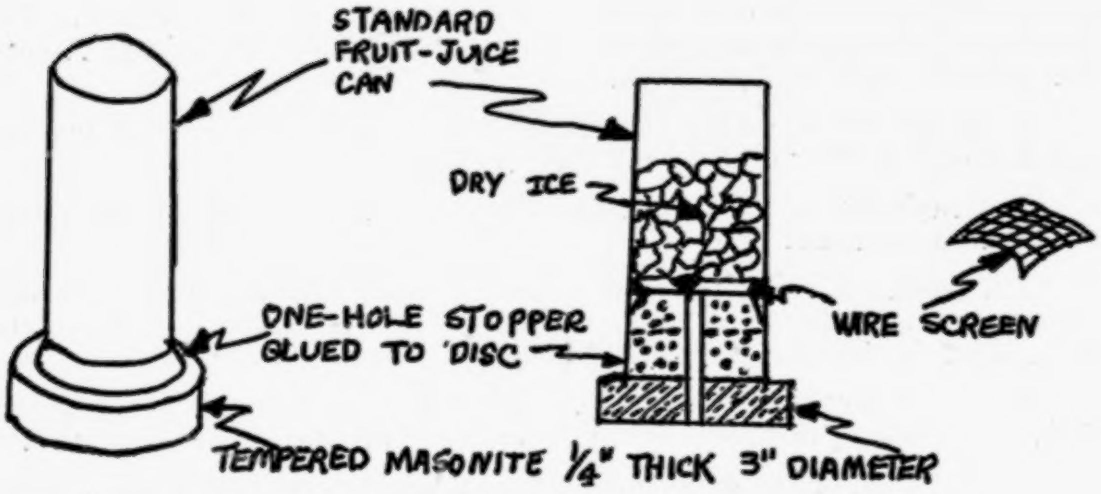

STANDARD FRUIT-JUICE CAN
DRY ICE
WIRE SCREEN
ONE-HOLE STOPPER GLUED TO DISC
TEMPERED MASONITE 1/4" THICK 3" DIAMETER

FIGURE 1
DRY ICE PUCK

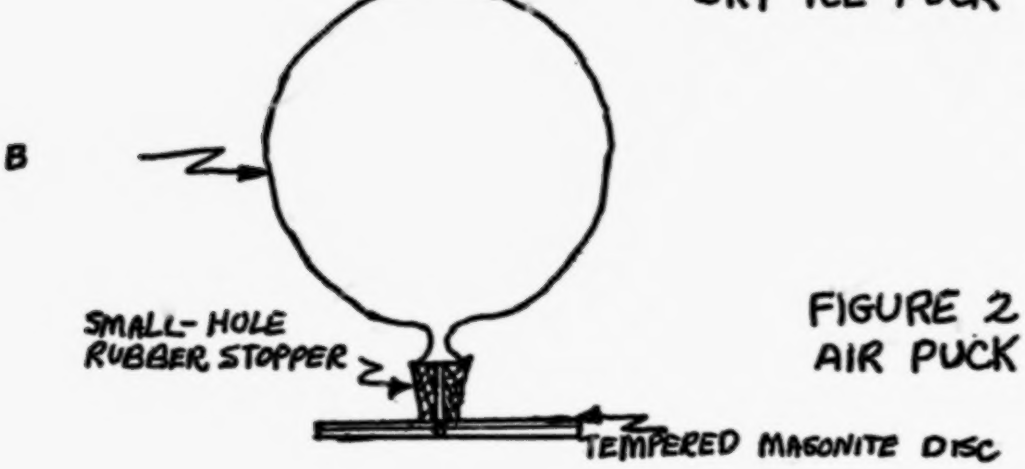

B
SMALL-HOLE RUBBER STOPPER
TEMPERED MASONITE DISC

FIGURE 2
AIR PUCK

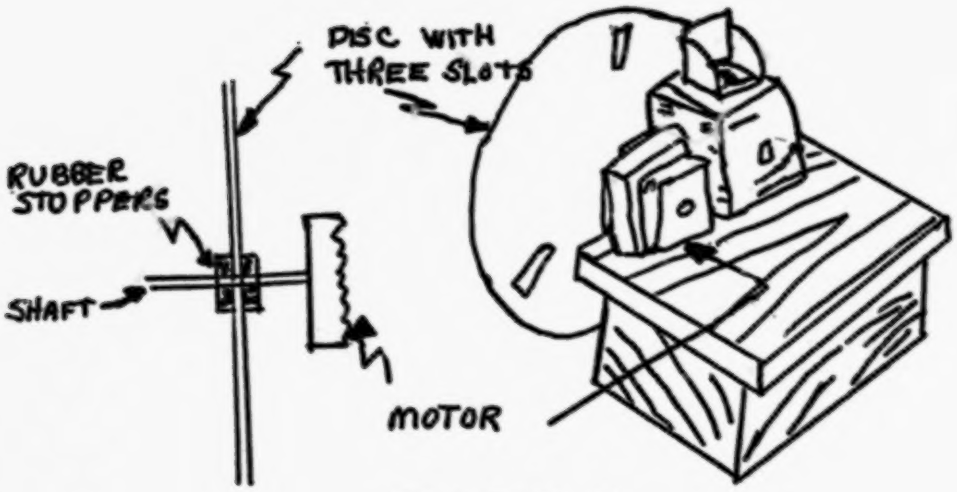

DISC WITH THREE SLOTS
RUBBER STOPPERS
SHAFT
MOTOR

FIGURE 3
STROBE DISC TIMER

Note — B, at center, is a balloon

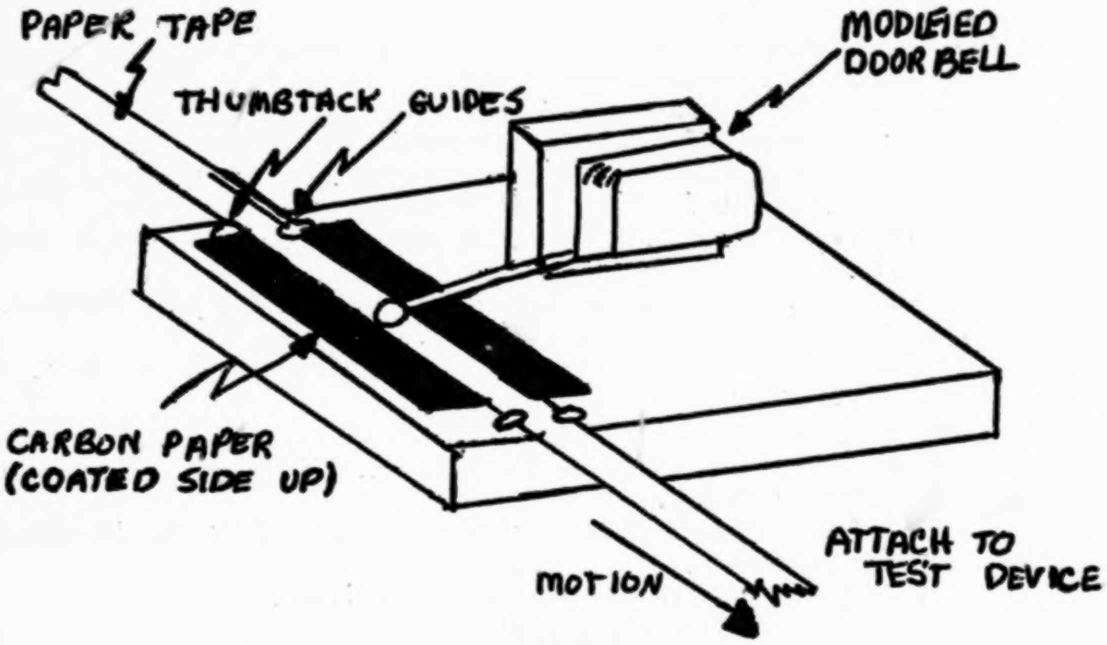

PAPER TAPE
THUMBTACK GUIDES
MODIFIED DOOR BELL
CARBON PAPER (COATED SIDE UP)
MOTION
ATTACH TO TEST DEVICE

FIGURE 4
BELL TIMER

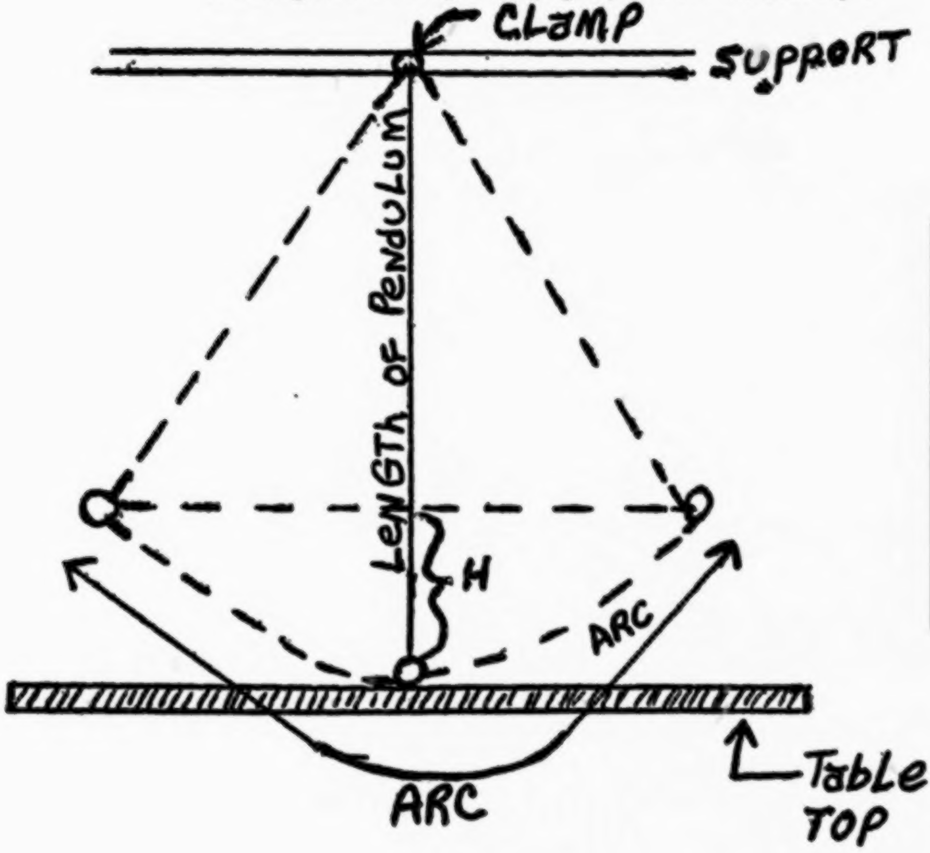
STUDY OF THE PENDULUM

Problem: What effect does the weight of a pendulum and the length of the pendulum have on its behavior?

Material: Upright support with extension
100 gram weight and 50 gram weight or two balls of different known weights.
String.
Yardstick or meter stick.

Activity Attach the 100 gram weight to the string and then by loop to the extension of the crossbar.
The weight should just clear the table top as it swings in an arc. Set the pendulum swinging in wide arc and note its height above the table so you can duplicate the arc as needed.
Count the number of complete arcs the pendulum makes per minute.
Record results.
Shorten the arc and repeat as before. Record results.
Change the weight to 50 grams.
Repeat the wide and small arc as done above. Record results.
Record results on arcs of other weights if you have time.
What effect did changing the weight have on the number of arcs per minute?
Change the length of the pendulum and repeat the work done above.
What effect does the change in the length of the pendulum have on the number of arcs per minute?
What application of the pendulum principle do we have in everyday life?

Conclusion: Based on the facts you recorded above, make a statement of fact about the relationship between the weight, pendulum length, and its arc.
Check this statement against the findings of Galileo in regard to the pendulum.
What part does gravity play in this activity?



Challenge:
Using a metal extension tape determine the length neded to illustrate 2-4 time in music; 4-4 time; Try others. Write up your findings and be able to demonstrate. Is this like a metromome? Explain.

Extended Experiment:

a. Show the relationship of kinetic energy and potential energy and calculate the velocity of the pendulum at the midpoint of its swing.

Facts In this Case:

Potential energy=Wh (where W is weight and h is vertical height lifted)

Kinetic energy=$\frac{1}{2}$ W/g V^2

The velocity, V may be found by equating the two formulas, (transfer of energy).

$$\frac{1}{2} W/g\, V^2 = Wh$$

$$V^2 = \frac{h}{\frac{1}{2}g}$$

$$V = \sqrt{2gh}$$

Knowing g as 32 ft/sec^2 or 980 cm/sec^2 the velocity is readily calculated.

Further exercise—Could the velocity of a bullet fired into and imbedded into a wooden pendulum bob be determined? How?

b. The pendulum formula, $T=2\pi\sqrt{l/g}$ is sometimes used to calculate the value of gravity. Determine the period of oscillation (T) of a pendulum; measure the length from the center of gravity to the point of attachment and sole for g, the value of gravity.

Note—An oscillation is the complete swing away from and back to the highest point.

DETERMINING LATITUDE

Exact location of the Earth is indicated by latitude and longitude. An instrument used to determine latitude is the sextant. You can construct a simple sextant and practice using it in determining latitude.

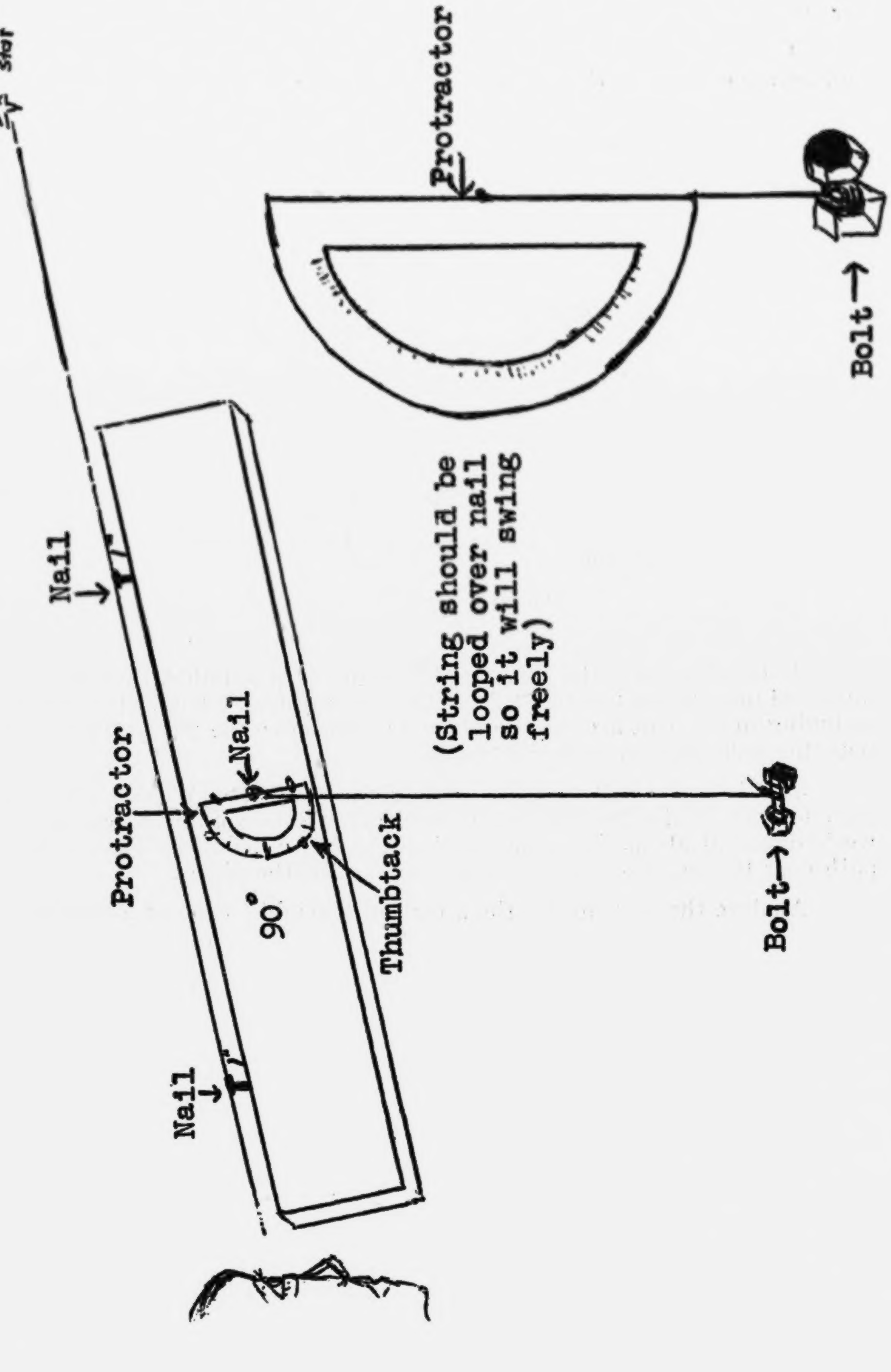
1. Collect the following materials: a protractor, a board, approximately 1" x 6" x 3', 3 nails, 4 thumb tacks, 2' of string, and a large nut and bolt to serve as a weight. Use the materials to construct a sextant like the one in the accompanying diagram.

2. Use a protractor to mount at 90 degree angles to the edge of the board.

3. Once you have checked the sextant, use it to determine the latitude of your home. On the first clear night, locate the North Star, Polaris. Hold your sextant so that the North Star is directly in line with the tops of the two nails in the top of the board. If you are sighting properly, the star should appear to be resting on the two nail heads.

Allow the weighted string to swing slightly and then come to rest. Hold the string tightly against the protractor. Read the angle indicated on the protractor, and record it in a table.

Repeat the procedure at least five more times. Record your reading in the table. Average the six readings and record the computation in the table.

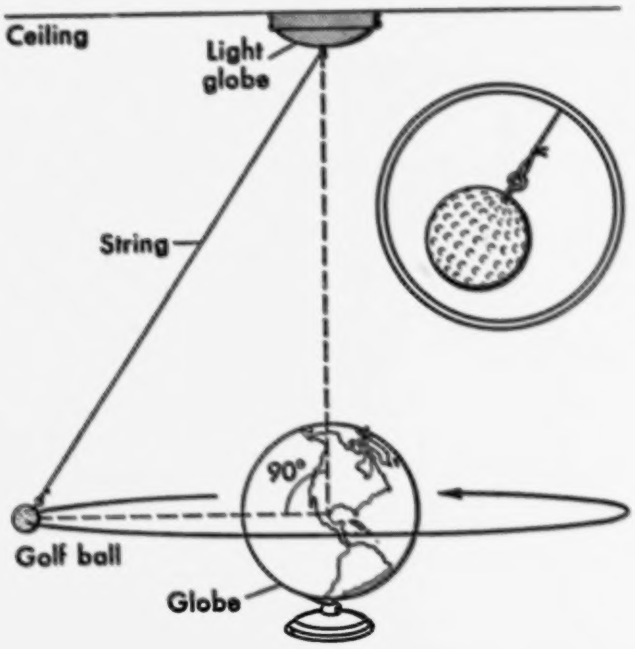

North Star
Nail
Nail
Protractor
Nail
Thumbtack
90°
Bolt→
Protractor
Bolt→

(String should be looped over nail so it will swing freely)

THE PATH OF THE SATELLITE

Maps which show the paths of satellites show them in a spiral pattern. Why? The activity described will help you understand the reasons for the strange path of a satellite.

1. Examine the drawing and collect the materials that are shown and arrange them as they appear in the diagram.



2. Imagine that the ball on the string is a satellite that has been launched toward the northeast from Cape Kennedy, Florida. Start the ball swinging in an orbit around the globe. Do not move the globe. Observe the path the ball takes around the "earth."

3. While the ball is still orbiting the earth, turn the earth from west to east. While the ball is still orbiting, try to rotate the globe from west to east at about the same speed as the ball is orbiting. What kind of path does the satellite trace over the surface of the globe?

Analyze the reasons for the apparent 'variable' path of a satellite.

SOME PROBLEM-SOLVING ACTIVITIES

ACTIVITY A.

Place a pinch (0.5 g) of calcium hydroxide on a piece of filter paper. Carefully pass it under your nose.

Place a pinch (0.5) of ammonium chloride on another piece of filter paper. Test it for odor.

Mix the two compounds together in the palm of one hand. Rub the palms together and bring the palms near the nose. What results do you get? Moisten a piece of red litmus paper and hold above your palm. What is the result?

WASH YOUR HANDS THOROUGHLY.

ACTIVITY B.

READ THIS EXPERIMENT THROUGH BEFORE PROCEEDING.

1. List the supplies and equipment you will need. Then get all supplies and equipment before you start the experiment.
2. Mix 5 g of NH_4Cl and 4 g of $Ca(OH)_2$ with distilled H_2O on a piece of filter paper.
3. Moisten a piece of red litmus paper with distilled water and allow it to stick to the inside of test tube B, as shown in Figure 1.
4. Place the mixture of the two compounds in a test tube generator, mouth tilted downward, as shown in Figure 1. Then finish assembling the apparatus as shown.

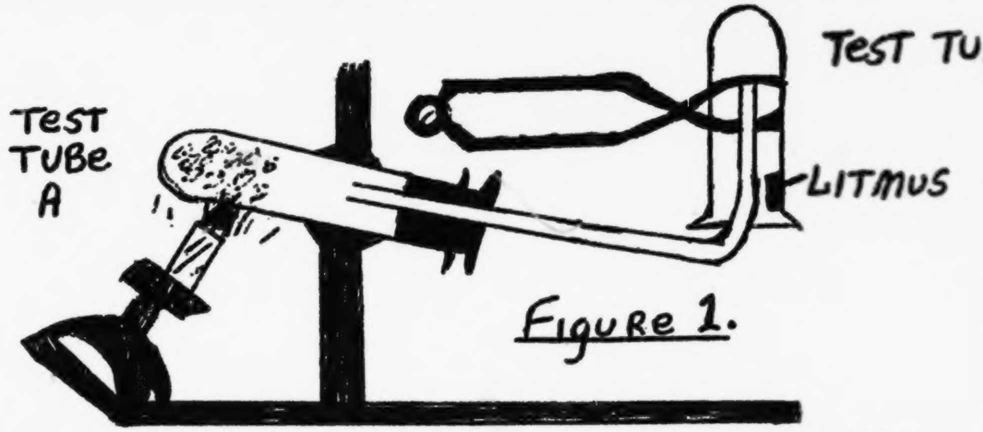


FIGURE 1.

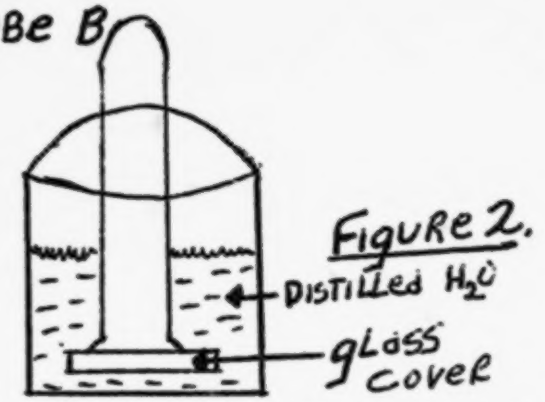


FIGURE 2.

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[1] Adapted from experiments in the *Sourcebook for Physical Sciences*, p. 250, and *Amsco Review Text in Chemistry*, p. 199.

5. Gently heat test tube A as shown. List any observations you make while the mixture is heating.

6 When the reaction is complete, or when otherwise instructed by the teacher, lift test tube B off the glass tube continuing to hold it mouth downward. Quickly cover with a glass cover slip. Immediately place another test tube mouth downward over the glass tube of the generator.

What indication do you have that the chemical reaction is taking place and that a gas has collected in test tube B?

Why is it necessary to hold the test tube mouth downward during the experiment?

7. Place the covered mouth of test tube B under the distilled water in the beaker as shown in Figure 2, and remove the cover. Keep tube under water until observed action stops. Then remove the tube. What happens? Why?

8. Collect four to six more tubes of gas and repeat step 7.

9. Test the water with red litmus or two drops of phenolphthalein solution. What happens? Why?

To what group of compounds does phenolphthalein and litmus paper belong?

10 Pour the water into the storage bottle used for this purpose.

11. Write the equation for the chemical reaction that took place with regard to Figure 1. What type of chemical reaction took place with regard to Figure 2. What type of chemical reaction is this?

ACTIVITY C.

1. Collect another test tube of gas and cover with a glass plate.
2. Take an empty test tube and place it in several drops of concentrated HCl. Cover with a glass plate and shake.
3. Invert the bottle and place on the mouth of the covered tube with the gas.
4. Withdraw the glass plates holding the mouths of the two tubes together. What happens?
5. Write the equation for the reaction. What type reaction is this?

SUMMARY:

1. What use could you make of the knowledge gained from each of these experiments—Act. A, Act. B, Act. C?
2. List the various techniques you learned or made use of in this experiment.
3. Complete the title of this experiment.

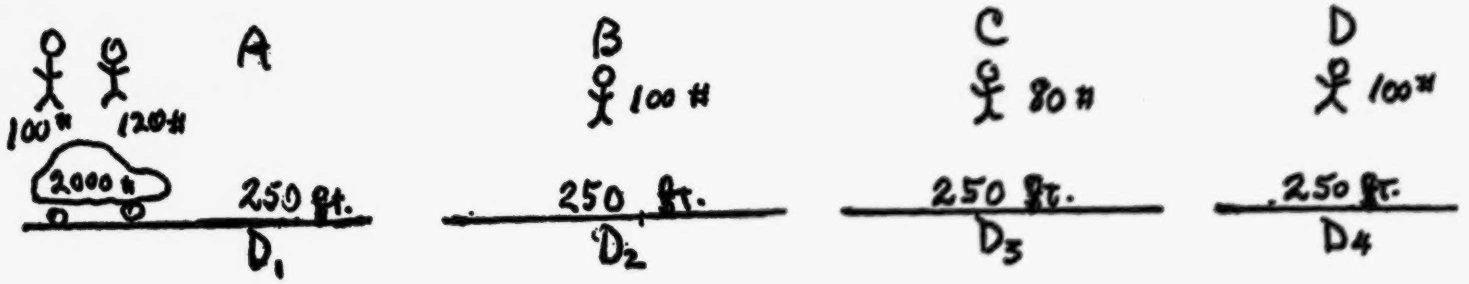
EXTENDED ACTIVITIES:

1. Look up other methods for preparing the substance resulting from the reactions in this experiment.
2. Look up the family of this compound and list the uses which are made of this family of compounds.

PROBLEM: COMBINING UNDERSTANDINGS OF FORCE AND MOTION.

ANSWER THE QUESTIONS AS RELATED TO THE DRAWINGS.

The boys in this drawing are having to push a stalled car to get it started. The force is given for each of the boys as they add their efforts at different points. The segments of the distance for the job are designated as D_1, D_2, D_3, and D_4. The small jobs required to complete the total work are indicated as A, B, C, and D.

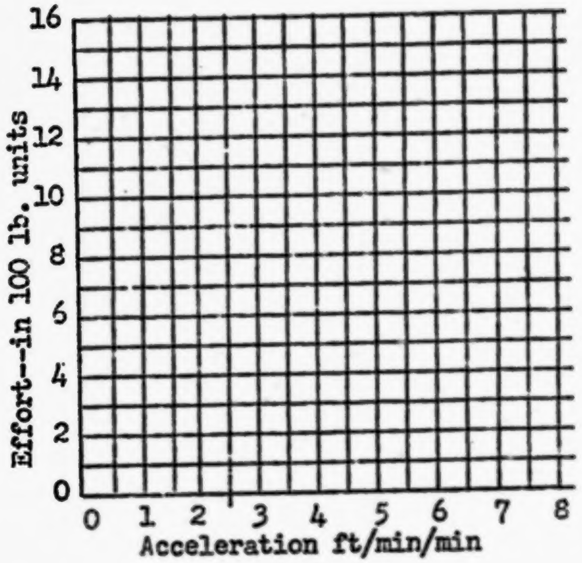


Time: 20 min. ____min. ____ min. ____min.

1. How much work is done in each of the small jobs? (Note: Work = FD, not WD)
2. What would the different accelerations be during each of the four periods? (Note that acceleration in D_1 is 1¼ ft./min./min. and acceleration is proportional to force.
3. What time would be required for D_2, D_3 and D_4?
4. What would be the average velocity for each period?
5. What is the total work done in getting the car started? Remember, all boys are at work through D_4
6. What would be the final velocity?
7. Fill in the chart next page with data from the problem. Using the proper formulas, calculate the other data.

8. Plot the ACCELERATION and the EFFORT on the graph below.

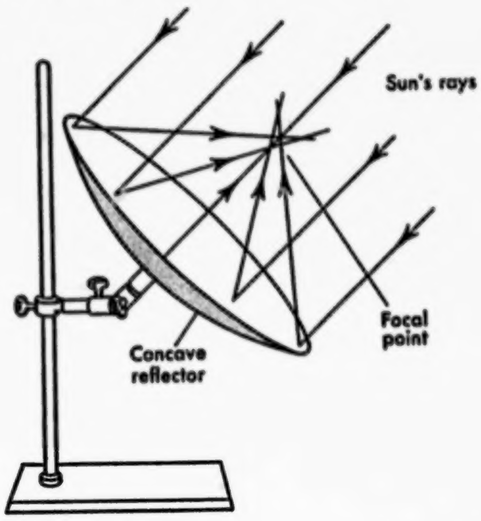
Seg-ment	E lbs.	d feet	t min.	v ft/min	a ft/min/min

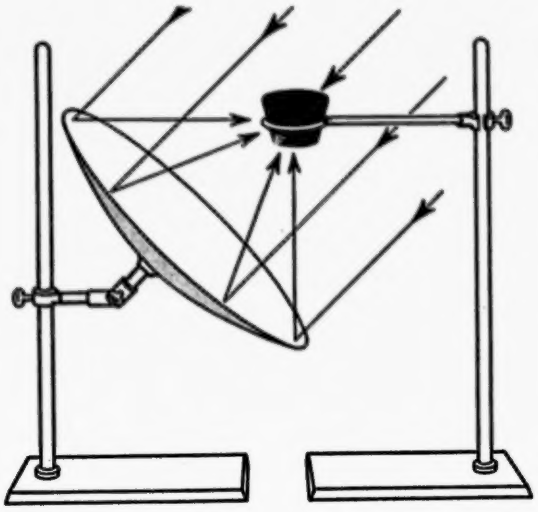


9. State your conclusions from the graph, writing it in the same form which is used in stating scientific principles.

USING SOLAR ENERGY

On a sunny day turn a concave reflector toward the sun and determine the location of the point where the parallel rays meet as shown in the accompanying picture. It is usually found at a distance from the center equal to one-half the radius of curvature of the reflector. This point is called the focal point. Fill a cup, which has already been painted black, with water. Record the temperature of the water. Set the cup in the ring support and position it at the focal point as illustrated in the second picture. After several minutes, record the temperature of the water. Is there a change? How could this be improved to give more heat? Could it be made a practical source of energy? Try to think of a way to convert this to other forms of energy.





MIRRORS AND LIGHT

Problem: How does the behavior of light rays differ when the rays strike curved surfaces?

Materials: Aluminum foil
Piece of styrofoam about 12 by 8 inches
Several small mirrors
Beaker or other cylindrical form
Piece of plain paper . . . no lines

Activity: Fold the foil several times to make a firm rectangle about 1 by 3 inches.

Curve the foil by pressing it against the sides of the cylinder.
Set the foil on the paper and turn it toward the sun or other source of light. Tilt the paper slightly toward the light source.
Find the point at which the rays come together.
Explain what happens.
Now turn the curved foil around, reversing its previous position.
What happens when this is placed in the light path?
Make a sketch of each position and show the light rays with lines.
Take the small mirrors and arrange them in a concave curve in the styrofoam pressing down on them lightly to embed them in the foam to hold them upright.

Expose this arrangement to the light and sketch the results.
Reverse the arrangement to convex and repeat the activity.
Sketch the results.
Write your conclusion in the form of two statements.

Extra activity: Repeat, using straight lines instead of curves. Compare or contrast the results.

LENSES AND LIGHT

Problem: How do lenses alter light rays?

Materials: Microscope slide, light wire loop about ¼" diameter)
Water
Erlenmeyer flask
Glass bead or marble (clear)
Concave lens and convex lens
Object to be viewed (Newsprint or a dime)

Activity: Place small piece of newsprint or a dime under a microscope slide.
Does the print change in any way? Explain
Add a drop of water to the slide over the object.
What happens? Explain
Try holding a drop of water on the wire loop and looking at the object through it.
Place a small amount of water in the flask. Stopper the flask.
Observe the newsprint or other object through the flask held on its side as you look through the water.
Try looking at the print through a clear marble or glass bead. How does this differ from previous observation through water?
Now observe the object you are working with through the concave lens and the convex lens. Describe what you see.
Which of the lens would a near sighted person need to correct his vision?

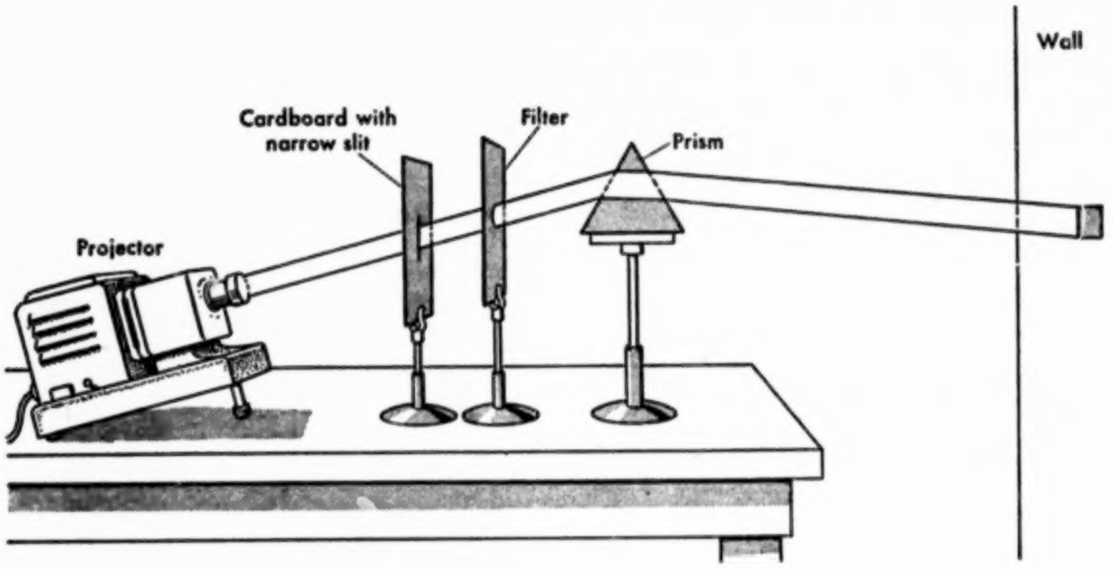
Research: What is the meaning of the word focus?
Make a sketch of the eye showing:
one nearsighted.
one farsighted.
How is focus concerned with near and farsightedness?

LIGHT AND COLOR

Visible radiation, or light, makes up only a small portion of the electromagnetic spectrum. Yet, this narrow band is important, since it contains the only radiation people can see. In this activity you will study how this visible radiation is related to color.

For the activity you will need these materials: a strong light source; two prisms; a piece of cardboard slightly larger than the lens of the projector; red, yellow, green and blue gelatin filters (available in most photography shops); and small squares of red, yellow, green, and blue cloth, or construction paper. You will also need to work in a room that can be darkened.

Arrange the equipment as indicated in the diagram (For activity 1 no filter should be used.).



1. Darken the room, then turn on the projector, focusing the beam of light on a wall on which you have fastened a large sheet of white paper. Insert one of the prisms in the beam of light and move until a clear color spectrum can be seen on the white surface.

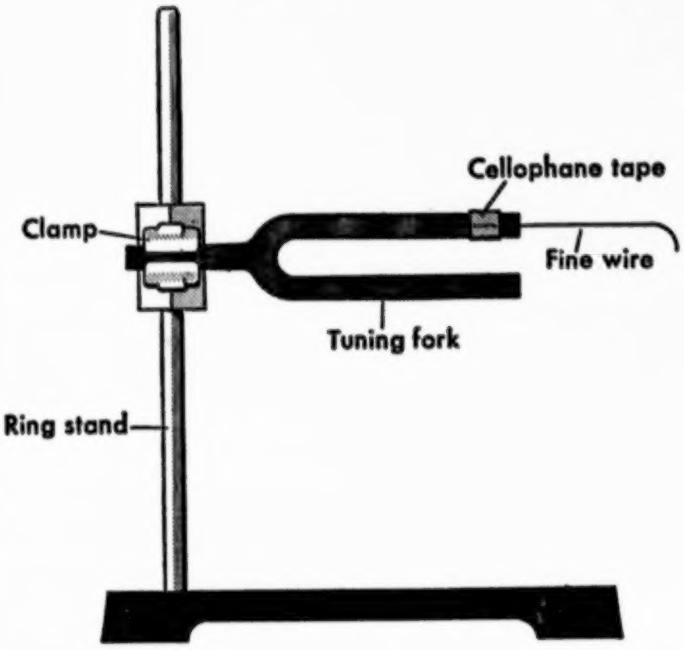
2. Hold the second prism about six inches from the first prism in the light that is transmitted by the first. Adjust the position of the second prism until a beam of white light falls on the white surface. (The two prisms are placed in such a manner that they are similar to a thick piece of glass with parallel faces). What happens to the beam of light?

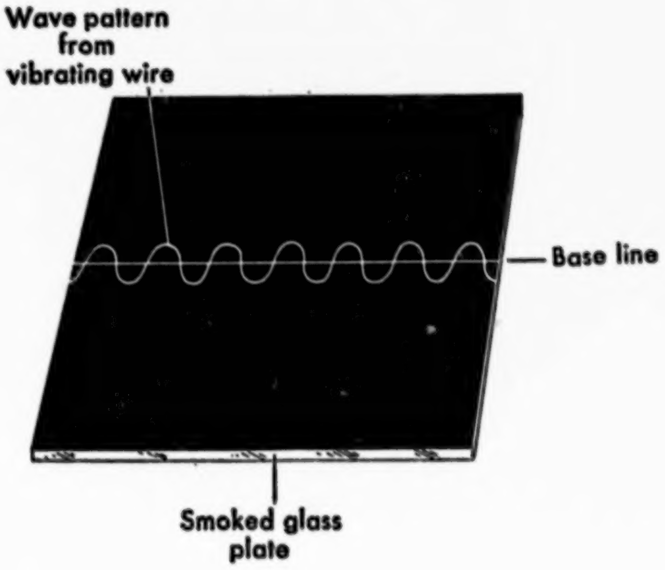
3. Remove the second prism. Then adjust the first prism so that a clear spectrum appears on the white surface. Insert the colored filters, one at a time, between the light source and the prism. Observe the effects on the spectrum. Place all the filters in between the light source and the prism at the same time. What do you observe?

4. Again adjust the prism to produce a clear spectrum on the white surface. Now hold each piece of cloth or paper, one at a time, in each of the colors of the spectrum. Observe the color that each sample of cloth or paper appears to be. Be sure the samples are pure colors not mixtures.

SOUND WAVES AND THEIR CHARACTERISTICS

In this activity you will "draw pictures" of wave patterns produced by using three different tuning forks. Use cellophane tape to secure the wire and set up as in the accompanying diagram.





Smoke six small glass plates, about 4 inches square. This can be done by holding the plate close to a candle flame. Hold the glass with gloves or tongs.

1. Gently strike the fork, causing it to vibrate. Hold one of the smoked glasses in a stationary position under the wire on the fork, so that the wire vibrates against the glass, drawing a line on it. Repeat the same procedure, this time striking the tuning fork harder and holding the glass in a new position.

Repeat this procedure with each of the remaining forks. Summarize your observations.

2. On each of the remaining smoked glass plates, draw a straight base line with the point of a sharp pencil. Strike one of the tuning forks that is still attached to the clamp. This time place one end of the glass under the wire, and draw the glass rapidly toward you but at a constant speed. The vibrating wire should then make a wave pattern similar to the one shown in the accompanying diagram.

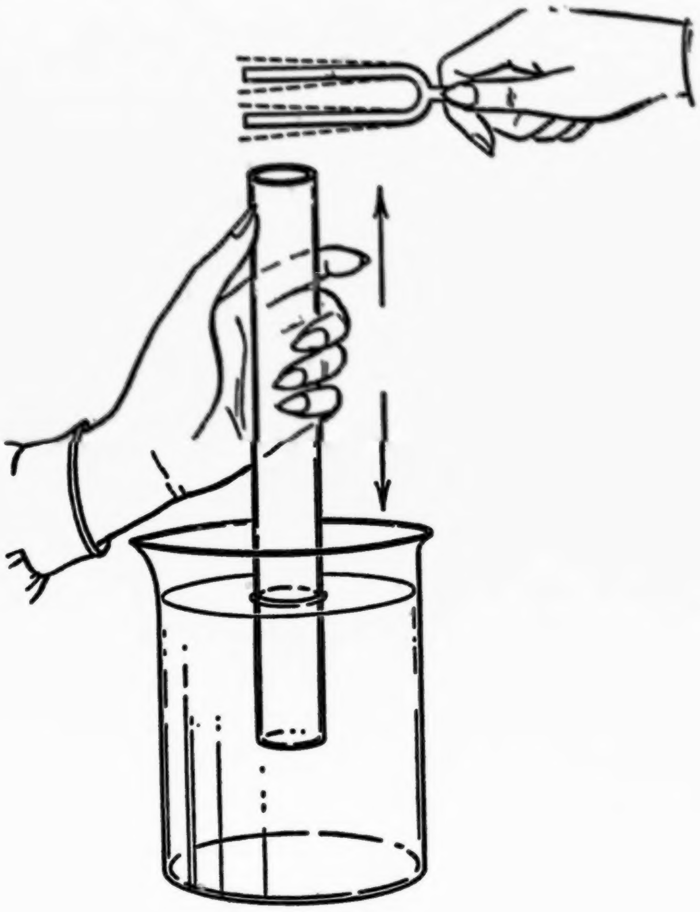
Repeat the procedure with each of the three tuning forks. Make sketches of the wave patterns that result.

RESONANCE

To study the effects of resonance place one end of a hollow glass tube in a 4000 ml beaker of water. Strike a tuning fork that vibrates at 256 vibrations per second on a rubber stopper. Hold the vibrating fork above the open end of the tube as shown in the accompanying picture.

Raise and lower the tuning fork and tube together. Notice the point at which the sound is much louder. Measure the length of the air column in centimeters at this point. Determine the wave length (use 1100 feet per second as the velocity of sound in air) and record these figures in a chart. Wave length = Velocity/Number of Vibrations$\frac{1100}{256}$ etc.

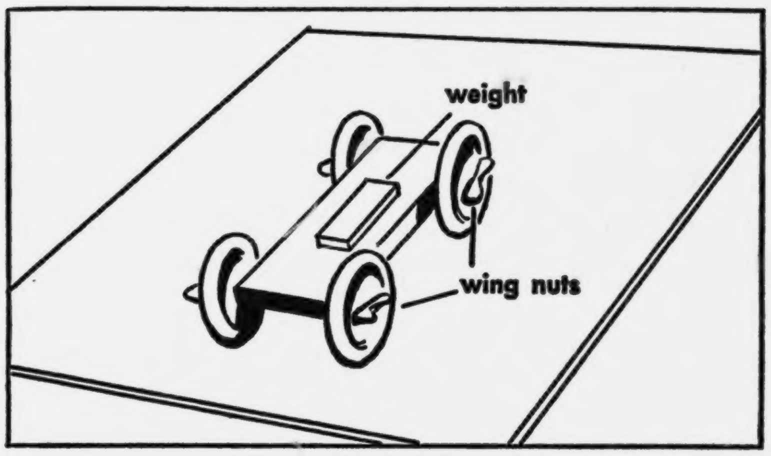
Repeat the experiment with tuning forks of several higher frequencies. What happens to the length of the air column when tuning forks of different frequencies are used? In each case, what relationship do you notice between wave length and the length of the air column?



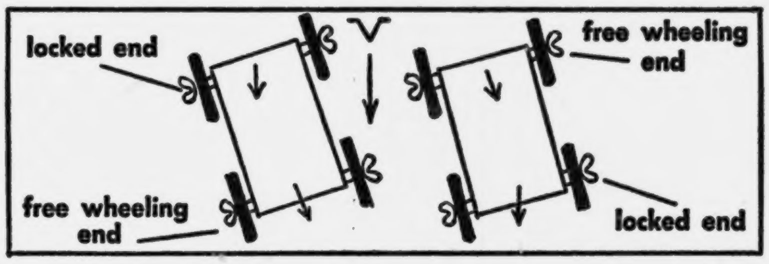
SOME APPLICATIONS OF FORCE

SKIDDING CARS. Should automobiles, with two-wheeled brakes, have these brakes on the rear wheels? Most people believe that they should be. The car illustrated may be used to show that this is not true. Each wheel is mounted independently and is held in place by a wing-nut on the outside end of the axle. The nut may be adjusted so that the wheel either runs freely or is rigidly clamped. (See drawing below.)

The car is permitted to slide down an inclined wet board. If the rear wheels are clamped the car reverses itself and slides down rear end first. If the front wheels are clamped the car slides down without skidding.



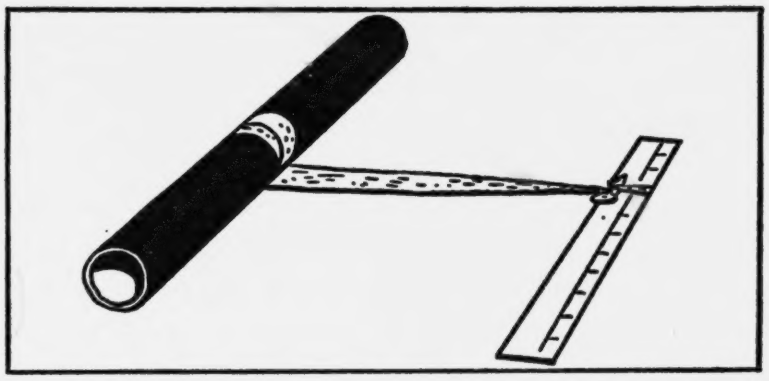
The simplest explanation. Assume the car is travelling in the direction of the arrow V but starts to skid. The free-wheeling end tends to go in a direction perpendicular to the axle—shown by the arrows on the figure below. The locked end tends to continue in the direction of V.



MOVING FLUIDS. Bernoulli's principle applies to fluids (air) in motion. Accordingly to this principle—at a point where the velocity is high, the pressure is less than at a point where the velocity is low.

This principle is used to explain the curving of a baseball. The curving ball may be illustrated with the simple equipment shown below.

This equipment is made by gluing felt to the outside of a mailing tube. One end of a cotton tape is attached with scotch tape to the tube and wound around it. The other end is tied to a meter stick. If the meter stick is swung like a baseball bat the tube is thrown forward and curves upward, making a complete loop.

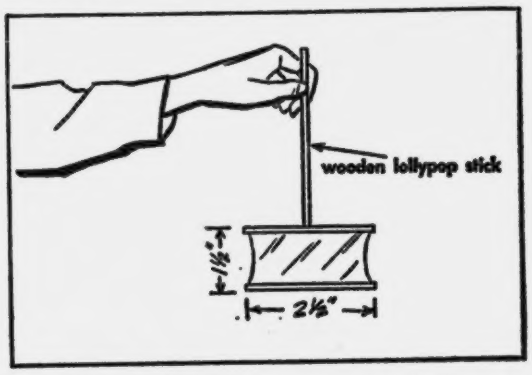


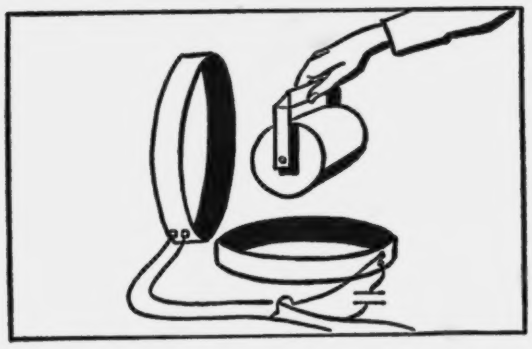
SURFACE TENSION. A rather graphic demonstration of surface tension is shown in the drawing on the next page. Two small horizontal thin wooden sticks are joined by a pair of threads. If this is dipped into a soap solution and removed, it takes the position shown. Some may like to think of this as showing that a free surface acts like a stretched membrane but it is perhaps better to think of it as showing that bodies tend to acquire minimum potential energy.

Since molecules in the surface of a liquid have more potential energy than those in the interior, decreasing the surface area decreases this potential energy. However, raising the lower stick increases the potential energy of the stick. The final position represents the minimum total potential energy.

INDUCTION MOTOR. Many students are surprised to learn that there are no electrical connections to the rotor of an induction motor. A model of a two-phase induction motor is illustrated in the drawing to the right. Two coils, one horizontal and one vertical, carry alternating current.

Placing a condenser in one of the lines produces a phase difference of almost 90 degrees and a rotating magnetic field. If a coffee can mounted on a spindle is held in the field it will rotate like a rotor in an induction motor.

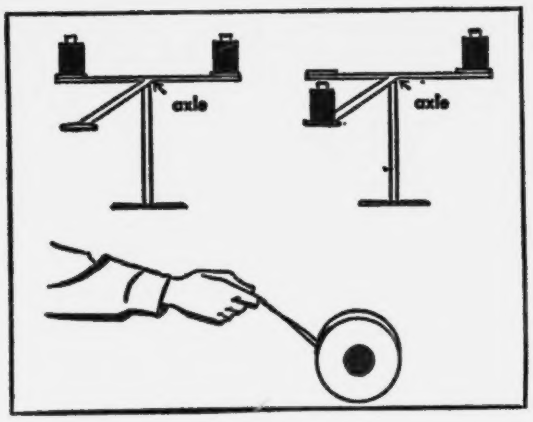




TORQUE. Torque is defined as the product of a force and its lever arm. If a body is in equilibrium, the sum of the clockwise torques is equal to the sum of the counterclockwise torques. (See below.) It is not surprising that a pair of one-kilogram weights produce equilibrium when placed on the platforms which are spaced equally distant from the fulcrum along the horizontal **member.**

Many students are surprised, however, that equilibrium is maintained when the left-hand weight is moved to the lower platform.

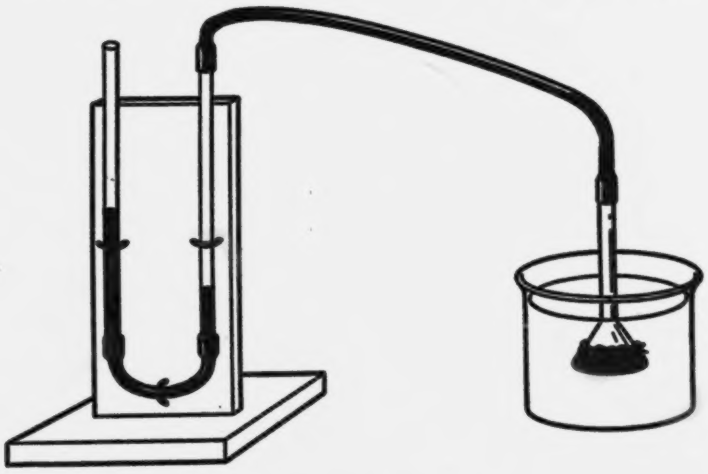
A spool and cord may also be used to demonstrate the principle of torques. Having fastened one end of the cord to the spool, wind it around the spool. Whether the spool rolls to the right, rolls to the left, or slides without rolling when the cord is pulled depends upon the angle at which the cord is held.



USING FORCES IN LIQUIDS

This experiment is to see if water pressure is equal in all directions at different depths by testing a sample with a manometer.

Attach a piece of U-shaped glass tubing to a wooden support with three nails as shown in the picture. Stretch a piece of thin rubber sheeting over the mouth of a long-stem funnel and secure it with string. Pour colored water into the U-tube until it is half filled. Attach the funnel to the manometer with a piece of rubber tubing. Push the funnel into a pail of water. Watch the manometer. Measure the pressure just below the surface and then at the bottom of the pail. At each level turn the funnel upward and twist it sideways. Does the pressure change with depth? Is water pressure equal in all directions at any one depth?



ELECTROMAGNET

INTRODUCTION

This experiment involves an electrical circuit including a switch. Be certain that the switch is open when the circuit is not in use. This is a low resistance circuit and if the switch remains closed for any length of time it will completely discharge the battery.

PURPOSE

To construct and study a simple electromagnet.

MATERIALS

#22 insulated copper magnet wire, large nail or soft iron rivet, small pile of ¾ inch flat head brad nails, two 1½ volt dry cells, connecting wires, knife switch, magnetic compass needle.

PROCEDURE

1. (A) Wind 25 turns of magnet wire on the soft iron core. Connect the electromagnet in series with the knife switch and one dry cell. Momentarily close the knife switch and pick up as many brads on the end of the core as possible. Open the switch. Count and record the number of brads.

   (B) Wind 25 more turns on the core (50 in all) and repeat the procedure as in 1-A above. Record the number of brads lifted by the core.

2. (A) Repeat #1-B above (50 turns) by using two 1½ volt dry cells connected in series as an electromotive source. Record the number of brads now attracted to the core.

   (B) With the magnetic compass needle, determine which end of the electromagnet is a north pole. Change the direction of the current through the electromagnetic coil by reversing the battery connections. Again determine the north pole of the electromagnet.

3. (A) Slip out the iron core from the electromagnetic coil so that the electromagnet now has an air core. Attempt to pick up brads by using the electromagnet now with an air core. Record the number of brads attracted.

   (B) By using the magnetic compass needle, determine the north pole of the air core.

CONCLUSION

1. What seems to be the relationship between the number of turns of wire and the strength of the electromagnet?
2. By increasing the voltage of the source as it is connected to the same length of wire, or resistance, and observing Ohm's Law, what quantity have you increased in the electromagnetic coil? State how this electrical quantity is related to the strength of the electromagnet.
3. What is the effect of the core material on the strength of the electromagnet?
4. Make a statement about the relation of current flow to polarity of the electromagnet.

FURTHER RESEARCH

1. What effect will be observed by using other materials such as core materials; copper, brass, wood, etc.?
2. What effect will be observed by making a "short fat" coil on the end of the core as opposed to a long thin coil?
3. What effect would be observed by using a hard steel bolt for a core rather than the soft iron rivet?
4. What would happen to an electromagnet if half of its coil had reversed windings?

PARALLEL CIRCUITS

INTRODUCTION

Read the safety precautions on the use of meters, switches, and care of equipment before proceeding on the experiment.

PURPOSE

To study the relationship between current, voltage, and resistance of resistors connected in a parallel circuit.

MATERIALS

Copper wire #20 insulated, knife switch, 2-1½ volt dry cells, a D. C. voltmeter—(0-5 volts), a D.C. ammeter (0-1 amp.), 3 flashlight bulbs as resistors, 3 bulb sockets.

PURPOSE—To study the relationship between current, voltage, and resistance when resistors are connected in parallel.

PROCEDURE

1. Connect three bulbs and a battery of two dry cells in parallel.
2. Connect the ammeter and knife switch in series between the battery of cells and the first resistor.
3. Unscrew the two bulbs farthest away from the battery. Close the switch and record the current flow through the ammeter.
4. Repeat this procedure and ammeter readings when two bulbs are lighted, and finally with all three lighted. Record the current flow in each instance.
5. Repeat the above procedure, but measuring the voltage across each lamp, with the first bulb lighted, then two, and finally all three bulbs lighted.

TABULATION

No. of resistor	Voltage	Amperage	Calculated Resistance
R1			
R1 + R2			
R1 + R2 + R3			

OBSERVATIONS AND CALCULATIONS

Calculate by the use of Ohm's Law the resistance of R_1, $R_1 + R_2$, and $R_1 + R_2 + R_3$. Record the calculated resistance in the last column of the table.

Make a drawing of this circuit.

CONCLUSIONS

What is significant about the voltage across a parallel circuit?

How does the total resistance of a parallel circuit change as the number of resistors is increased?

FURTHER RESEARCH

1. If all three lamps are lighted in the parallel circuit, can you predict the voltage that would be measured across the first, second, and third resistor?
2. What would be the effect of using three different sized resistors in the parallel circuit?
3. What amount of heat is liberated by different sized resistors in parallel?
4. Can you predict the effect on resistance caused by using combinations of resistors in both series and parallel?

SERIES CIRCUITS

INTRODUCTION

Read the safety precautions on the use of meters, switches, and the care of equipment before proceeding on the experiment. Remember, have the switch closed only while you are determining voltmeter and ammeter readings. Keep the *switch open* at all other times.

PURPOSE

To measure the resistance of resistors connected in series and the total resistance of the circuit.

MATERIALS

Copper wire #20 insulated, knife switch, 2-1½ volt dry cells, a D.C. voltmeter (0-5 volts), a D.C. ammeter (0-1 amp), 3 flashlight bulbs as resistors, and 3 bulb sockets.

PROCEDURE

1. Connect the two batteries — to + which is in series, then connecting the three bulbs, knife switch, and the ammeter forming a complete path.
2. Place the voltmeter across the terminals of the first bulb and close the switch. Read and record the readings in the table. Open the knife switch.
3. Move the voltmeter across the terminals of the second bulb, close the switch long enough to take meter readings.
4. Repeat for the third bulb.
5. Open the switch and place the voltmeter across all three resistors, on the outside terminal of the first and third bulbs. Close the switch and record the readings in the table.

TABULATION

No. of resistor	Voltage	Amperage	Calculated resistance
R1			
R2			
R3			
R4			

CALCULATIONS AND OBSERVATIONS

1. Find the resistance of each bulb by use of Ohm's Law.
2. Find the total resistance of the circuit by use of Ohm's Law.
3. How does the voltage in each resistor compare?
4. How does the sum of the individual voltages compare with the voltage across all three?
5. How does the sum of the resistances compare with the total resistance?
6. Make a drawing of the circuit using the necessary symbols.

CONCLUSION

1. Make a general statement about total voltage in a series circuit.
2. Make a general statement about total resistance in a series circuit.

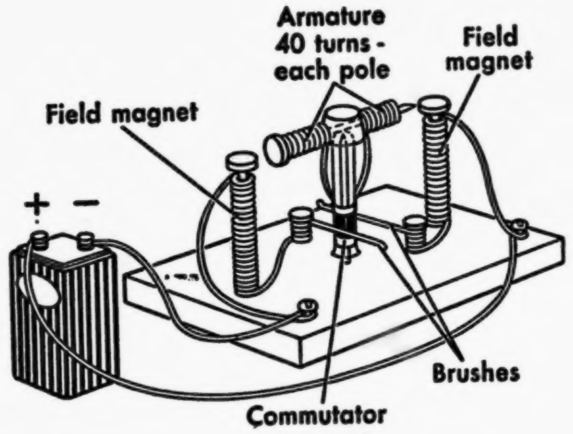
FURTHER RESEARCH

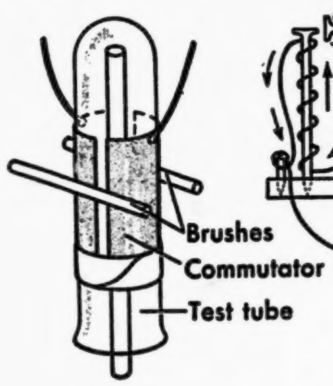
1. What is the effect of different size resistors in series on voltage and current?
2. What is the effect of different material as resistors in series?
3. What is the effect of the length and the cross-sectional area of different materials as resistors in series?
4. What is the heating effect of resistors in series?

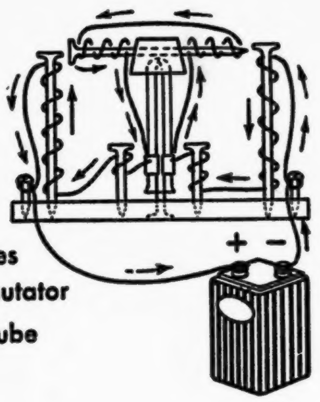
AN ELECTRIC MOTOR

You will need: a board about 8" x 10"; three 6" nails and one 5" nail; two smaller nails and screws; test tube; insulated No. 24 copper wire; 2" cork; two strips of sheet copper. 1½ x 1"; electrician's tape; one or two dry cells.

Armature. Drill a small hole through the center of a board and drive a 6" nail through it. Turn the board over so that the nail rises from the lower side. Drill a hole through the 2" cork and force a 5" nail through it. Wind about 40 turns of wire onto each end of the 5" nail; following the diagram carefully. Note that the direction of winding on the head end of the nail is opposite from that on the point end. Leave five inches of wire on each free end. Strip the insulation from the ends and scrape the tips.







Gouge out the cork neatly, so that the closed end of the test tube just fits. Insert the test tube.

Field magnets and brushes. Wind 100 turns of wire on each of the two 6-inch nails, clockwise on one, counter-clockwise on the other. Drive nails into the base 5½ inches apart and equally distant from the center nail. Drive two small nails into the board, diagonally from the line connecting the large nails and each 2" from the center. Strip the free ends of the wires and wind them several times around the small nails, leaving ends. Arrange the scraped wire ends so that they touch the central nail. These are your brushes.

Commutator: Wrap the two strips of copper around the open end of the test tube. Trim if necessary so that there is about one-fourth gap between the ends, on each side of the tube. Punch a small hole in each strip and attach a free end of the armature winding. Then bind the strips into position on the test tube with adhesive tape, top and bottom.

Assembly. Set the test tube carrying the armature into position on the center spike. Bring the brushes into contact with the commutator. Connect the long free ends of the field magnet windings to the poles of one or two dry cells and give the armature a slight push. It should revolve rapidly. If it does not, check your windings and make sure they follow the diagram. You may find that a slightly different position of brushes will help. Holding them always parallel, try different angles while a classmate spins the armature.

AN EXAMPLE OF FLUID INQUIRY

Topic: Rocketry

Understanding being discussed at the time of the situation: When a rocket is being launched, it has to 'overcome' the force of gravity and the resistance of the air through which it travels.

I. *State an answerable problem:* Previous study, displays of rocket models, bulletin boards with charts or rocket trajectory, etc. will stimulate interest and initiate questions such as:

A. Why are rockets not shaped like airplanes?

B. Why are airplanes not shaped like rockets?

C. Why are some rockets needle nosed, some like ice cream cones?

D. Why not make them like flying saucers?

E. Some satellites are ball-like, why aren't rockets?

Show the students through guided discussion that these questions are unanswerable in the manner in which they are stated. It can be proposed that the prime question would be: "Why are rockets shaped like they are?" Of course someone will probably say: "They work better that way." To this another student will retort: "How do you know?" Then the possible comment of: "What *way* are you talking about?" At this point it would be wise to narrow the field of discussion into a hypothesis.

II. *State hypothesis that can be tested:* Analyze the questions as contributed above from the standpoint of what could be practically tested in the classroom environment. Many side issues will arise but can be guided into establishing hypothesis: Shape of the nose cone effects the launching of rockets.

III. Introduce the term *"assumption"* to your students as compared to the term "fact." Test the discussion which has occurred separating facts from assumptions. It will be found that you are *assuming:* That due to your past experience you hold certain shapes to be used on nose cones of rockets. (Existence of models in classrooms or pictures is literal proof of this.) Establish that we are dealing with the *fact:* that we know from the laws of motion that shape is involved in overcoming air resistance.

IV. *Plan to test:* Students can draw on the board the suggested shapes which might be used and narrow the selection to three: Ice cream cone shaped (slightly flat on top), moderate nose, needle nose. This leads into: "What are we going to use as the rocket body?" followed by: "How are we going to propel it?" Eventually balloons can be selected as the vehicle. This leads to: "Round balloons, twisted balloons, or long balloons?" The logical selection will be the long balloons. Questions will arise (and if they do not the teacher should inject them in suitable places) concerning the (1) length and diameter of the inflated balloons to be used kept consistent (2) effect of adding a cardboard cylinder to the mouth of the balloon to simulate real rocket control of the escaping gas and (3) the assumptions which will necessarily become a part of the set-up concerning the age and material of the balloons used in multiple.

Nose cones will have to be established to be constructed of tag board or similar material. These cones present the problem of: "How will we hitch them on to the balloons?" Masking tape, Scotch Magic tape, adhesive-all may be suggested and the end decision may vary in different schools. A guide control system is now in order. This can be tossed around and finally established similar to Figure 1 on the attached sheet. Note that here are shown factors which the students or teacher must expand to more nearly simulate the real conditions of atmospheric characteristics; namely; the fan to increase air resistance, and movement as involved with speed, etc., and the slant to the string also contributing to the resistance as well as reinforcing the trajectory pattern.

At this point the teacher has a natural lead into some exploration and learning about *statistical* data as a part of testing. A chart can be worked out by the students to record the data from the test flights similar to the one shown in Fig. 2 on the attached sheet. To record this, three teams of two students each should deal with time and distance measurement. The number of experimental launchings should be stressed as good scientific procedure since every good scientist accepts only evidence based upon a number of observations. As much control can be planned as the students and teacher find necessary or practical in the environment.

V. *Conduct experiments:* Conduct the experiments as planned in multiple (four launchings to each nose cone). Be sure to maintain standard controls. It may become necessary to modify the guide system. (For example, the fan may offer too much resistance or the angle of the line may not be compatible to the rockets or air pressure or the length and diameter of the rocket body, or the construction of the rocket nose.) It is good for the students to realize that their tests may not run smoothly and that this is part of conducting scientific inquiry. Be sure that the students realize the value of "average" figures on the test results in correcting some variables, as well as the value of having teams of students recording a control on variances in observation due to the "human" angle.

VI. *Observe accurately and objectively:* Furnish the students with mimeographed outlines of the chart set up for recording and have each record the data as it is obtained. It would be well to have each student also write down any additional observation that he makes on the experiment and these will be collected for use in summarizing the findings. Stress the importance of being sure you saw what you report and avoid the "assumptions" or extensions of imagination. Previous to conducting the experiment settle on the units to be used in mathematical data; metric or other. This should be consistently followed so that all records will coordinate.

VII. *Organize data and construct generalization:* The crucial point in teaching the value of statistical data in testing will be at this point in the inquiry. Here the data can become "live" and meaningful according to what the teacher does with it. Chalkboard summaries of the data in form of graphs done in color giving time and distance coordinates, overhead projector graphs, and illustrations of the numerical differences are a few ways to highlight the data.

VIII. *Apply generalizations to hypothesis:* After organizing the data, help the students examine it for generalizations. (Discuss the difference between a hypothesis and a generalization). Possibly the only generalizations would be: (a) that there is a noticeable effect of shape on launching, or (b) the results are inconclusive. If the latter is the case, hold an open discussion as to "why." This will point out the error and possibly the revision necessary. It could lead to a realization that newer or more valid line of inquiry is indicated. Actually placing the generalizations and hypothesis side by side on the board will make it easy for the students to arrive, or be led, to the desired end.

ROCKETRY

Draw conclusions supported only by evidence: This inquiry will prove to be "open-ended". It is possible that these or other routes may be pursued: (a) distance and time curves (b) discussion in dealing with error in measuring, recording, etc. (c) limitations of variables.

Cone	Trial	Distance	Time
1	1		
1	2		
1	3		
1	Avg.		
2	1		
2	2		
2	3		
2	Avg.		
3	1		
3	2		
3	3		
3	Avg.		

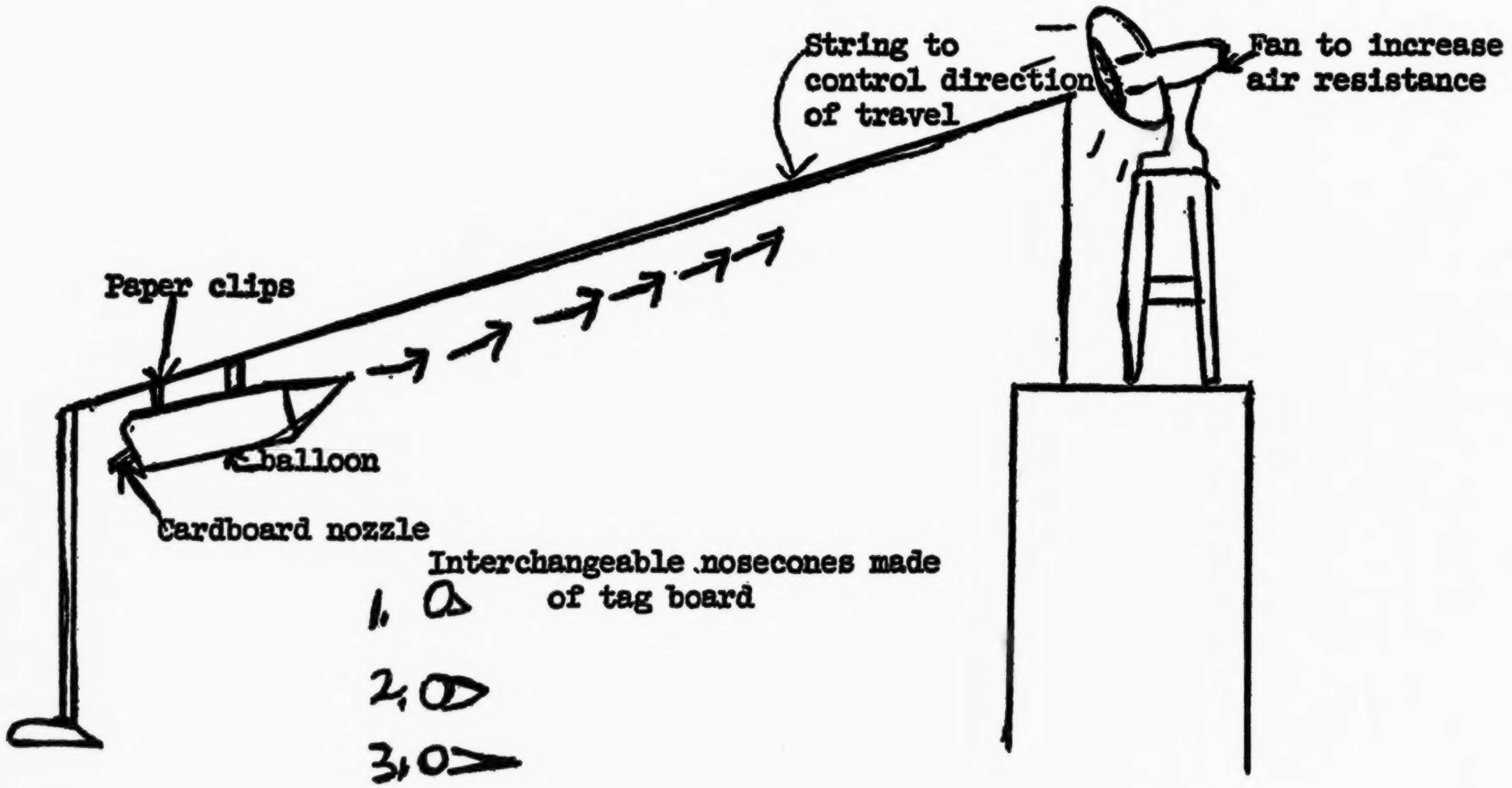
Figure 2

Stop watch to measure time of travel.

Tape-measure distance of travel.

(measure guide string from point where front guide clip starts travel to farthest point that this clip reaches as determined by observers.)

* Use three observations of each measure of time and distance. Average these to get the trial distance and time.


String to control direction of travel
Fan to increase air resistance
Paper clips
balloon
Cardboard nozzle
Interchangeable nosecones made of tag board
1.
2.
3.

ANOTHER EXAMPLE OF FLUID INQUIRY

(The following example of problem solving approximates the situation of the scientist. It is designed for a classroom situation in which more than one approach is used. Refer to Methods of Science (Skills in the Processes), 7th grade, for a general outline.

From class discussions, questions regarding atmospheric pressure will arise. Some of these questions might be as follows:

Why does the air have weight?

Why don't I feel air pressure on my body?

What is a vacuum?

Such questions should be written on the chalkboard and analyzed. Out of this should come an answerable problem. For example,

1. Problem—to show that air has weight and thereby exerts pressure.

2. Hypothesis: Air is material that occupies space and has weight.

3. Write out hypothesis on the chalkboard and point out the following assumption: We assume that air is matter. If it is not we should be unable to prove the hypothesis by this method. If we can prove that air occupies space and has weight, then it satisfies the hypothesis, thereby answering the problem.

4. Through discussion, have students suggest investigations and/or experiments which will test the hypothesis. Examples follow:

    a. Use an air thermometer (simple form) or a Florence flask with a one-hole stopper through which a glass tube about one foot long is inserted. Invert and arrange so that the tube extends into a beaker of water. Apply heat to the flask for a number of minutes. After sufficient air has escaped, remove the beaker, plug the opening in the tube with soft paraffin, and remove the heat, in that order. Allow to cool, then weigh. Remove the plug and weigh again, remembering to weigh the plug along with the flask. The experiment may be repeated for enrichment, this time allowing the flask to cool while the tube remains in the beaker. This will show the approximate volume of air expelled in the process and will demonstrate that since air could not return to the flask, the water took its place.

    b. Do the varnish can experiment found in almost any text. (Do not use duplicator can from office without sufficient rinsing.)

    c. Place a yard stick on a table with about half of the stock extending beyond the table edge. Place several layers of newspapers spread out over the end of the stick on the table. Strike the end of the stick extending with a hammer. It should break clean and quickly. Measure the paper, multiply by 15 (lb/in^2) to find force exerted on the stick. Repeat, using the same paper, wadded or rolled up in a ball.

    d. *Boil water in Florence flask at less than 212 F.* Bring H_2O to boil. Cap with a stopper inserted with a thermometer. Cool flask slowly under running water. Note temp. at which water boils again.

5. Perform the above experiments, recording any and all observations.

6. Have students interpret their observations, such as,
    a. bubbles rise—air is coming out
    b. difference in weights—air has weight
    c. sound of air may be heard when unstoppered—air is returning
    d. steam escaping—can contained air and water before boiling and a less dense mixture remains in the can—can collapses because of an inbalance in pressures outside and inside, rather than a suction inside pulling in the sides.
    e. with yardstick, interpret differences in the procedures, correlating with differences in results.
    f. enrichment and reinforcement of hypothesis may be given by showing that reduced pressure above free surface of liquid results in lowering the temperature at which water boils.

7. From recorded data (observations) allow the class to arrive at a general statement:

   air occupies space
   Since ↕
   air has weight , air is matter.

8. Examine results to see if retesting or additional experiments are needed to prove stated problem.

9. Discuss relationship of results to hypothesis, and draw conclusion in relation to the stated problem.

ACTIVITIES USING PROCESS TEACHING

(Adapted from *Selected Science Services*,
United States Department of Health, Education, and Welfare,
April, 1963.)

Process teaching is not new. It is essentially a matter of emphasis. The most commonplace topic in science can be made into a challenging lesson simply by a slight shift in emphasis. Among the processes of inquiry which must be stressed are: (1) problem recognition; (2) problem definition; (3) observation; (4) collection, analysis, and interpretation of data; (5) hypothesizing; (6) generalizing.

Several learning situations utilizing this approach are presented below.

(1) *The Siphon:*

a. Silent demonstration of siphon using colored water. A siphon can be made from two pieces of glass tubing, each about 8 to 10 inches long, connected by a rubber tube of the same length. Fill two milk bottles each about half full of water. Fill the siphon tube with water and pinch tightly at the rubber connection. Now place an end of the siphon in each of the bottles. Hold a bottle in each hand and manipulate one end of the siphon up and down.

b. Do you recognize a problem here?

c. How would you state the problem?

  (1) What makes the liquid move?

  (2) What causes the liquid to flow?

  (3) Under what consideration does the water in the siphon flow?

  (4) What factors influence the flow of a siphon?

d. Propose hypotheses for phenomena observed.

e. Suggest controlled experiments by means of which the hypotheses can be tested.

(2) *Rate of Flow of Siphons:*

a. Silent demonstration with siphon and colored water.

  (1) Large diameter—short tubes

  (2) Large diameter—long tubes

  (3) Medium diameter—short tubes

  (4) Medium diameter—long tubes

  (5) Small diameter—short tubes

  (6) Small diameter—long tubes

  (7) Other variations

b. List observations on blackboard.

c. What is the problem? Select best statement.

  (1) What factors influence the rate of flow of water through the siphon?

(2) Why does the water flow through the siphon at different speeds?

(3) What causes the water to flow through the siphon?

d. Propose hypotheses based on such factors as:

(1) Difference of levels

(2) Diameter of tubes

(3) Density of liquid

(4) Difference of liquid pressure

(5) Viscosity of liquid

(6) Internal friction of the tube

(7) Length of tubes

e. Attempt to state the hypotheses as a quantitative relationship.

f. Design a controlled experiment to test the influence of each factor in affecting the rate of flow.

g. Identify assumptions basic to the various experiments.

(3) *The Candle and Jar:*

a. Silent demonstration. Fasten candles of different sizes to the bottom of suitable pie tins with melted wax. The aluminum foil pans used for certain frozen foods work very well. After the candle has been lit with a match, cover with a jar. Try the following jar and candle combinations. Make careful observations. Repeat for accuracy. See if you can get measurements of any factors.

(1) Long thin candle—large jar

(2) Large diameter candle—large jar

(3) Large diameter candle—small jar

(4) Birthday candle—small jar

(5) Birthday candle—large jar

(6) Other variations

b. Discussion of observations (record on blackboard).

c. Testing various hypotheses.

d. Select most promising hypotheses.

e. Evaluation of evidence.

f. Interpretation of evidence.

g. Drawing generalizations.

(4) *Radiobiology:*

Problem: Do aquatic animals differ in their absorption of fission fallout materials from their water environment?

a. Propose hypotheses for solution of problem.

b. Design controlled experiment to test hypotheses.

c. Collect specimens such as minnows, crayfish, and salamanders.

d. Place specimen in approximately 20 millileters of water containing 2 milliliters of one microcurie per milliliter solutions of radioactive isotopes such as iodine^{131}, sodium^{22}, phosphorus^{32}, or sulfur^{35}.

e. Vary the periods of exposure up to 80 hours.

f. Design controls for each experiment.

g. Test evidence by change from background counts on a Geiger counter.

h. Make autoradiographs, varying the time exposures on x-ray film, of the different animals used.

i. Discuss possible errors in data.

j. Draw inferences from data.

k. Propose further tests of data as a basis for conclusions.

(5) *Effect of Temperature on Bacterial Growth:*

Using pure cultures of known bacteria, or ones isolated from air exposure plates, inoculate 3 sets of tubes of nutrient broth and/or nutrient agar slants and incubate at 37°C (incubator), 25-30°C (room), 5°C (refrigeration), and other temperatures. Record relative amount of growth for 3 to 7 days.

(6) *Inhibition of Bacterial Growth:*

a. Dissolve two beef bouillon cubes in a quart of warm water.
    (1) Divide the broth into eight equal portions and put into clean glass tumblers or breakers.
    (2) To glass No. 1 add a teaspoon of salt.
    (3) To glass No. 2 add a teaspoon of sugar.
    (4) To glass No. 3 add a tablespoon of sugar.
    (5) To glass No. 4 add a teaspoon of vinegar.
    (6) To glass No. 5 add a teaspoon of chlorox or other bleaching solution.
    (7) To glass No. 6 add a teaspoon of household ammonia.
    (8) To glass No. 7 add several drops of merthiolate or tincture of iodine.
    (9) Leave glass No. 8 untreated as a control.

b. Leave glasses at room temperature and observe at daily intervals for evidence of bacterial growth, either as increased turbidity or the development of a surface film.

c. Draw conclusions and relate them to control of bacteria.

(7) *Measuring the Oxygen Consumption of a Small Animal:*

a. Place an insect such as a grasshopper in a gas collecting bottle with a one-hole rubber stopper fitted with a 0.2 ml pipette. The pipette should contain a drop of ink. Insert several pipe cleaners soaked in a 0.4 percent solution of KOH (to absorb the CO_2) between the cork and the neck of the bottle. Gather similar data for a dead grasshopper and other live insects and small animals at different temperatures and rates of activity.

b. Chart changes in position of the drop of ink.

c. What is the problem? Select the best statement.

d. Propose hypotheses concerning oxygen consumption rate and

   (1) Size of insect

   (2) Degree of temperature

   (3) Relative activity of insect

   (4) Other factors

e. Study data to determine whether they support each hypothesis.

(8) *Inheritance of Taste Ability:*

a. It is not difficult to test for taste ability in the classroom. Give a taste ability test paper to each student. PTC test papers, as they are called, may be obtained from the American Genetic Association, 1507 M Street, N.W., Washington 5, D.C., at nominal price.

b. Record the number of those who can detect a bitter taste and those who cannot taste anything. Your students may then take papers home to test the members of their families.

c. Record statements of the problem and select the best one.

   (1) How many tasters would there be in a class if the law of averages alone controlled the results?

   (2) Are the results similar to those you would expect if the Mendelian laws applied?

TESTING HYPOTHESES

The sources of hypotheses are many. They come from laboratory work and demonstrations; observations of natural phenomena are common sources; the statements in science textbooks, often arbitrarily made, are hypotheses to the student who may read them as plausible but unverified statements.

In the following proposals, hypotheses from several sources are each accompanied by a suggestion of an initial approach to a test of the hypotheses and their accompanying suggestions will be most useful to the science teacher if a few precautions are observed:

(1) The hypothesis—suggestions should not be presented to the students as a laboratory experiment to be done. If there is a hypothesis, it must exist in the student's consciousness; it must be a result of his own thinking and doing.

(2) The suggestion is for the teacher to use judiciously with the student; it is presented only if needed and to the degree needed.

(3) Each suggestion could be accompanied by others; but students should be encouraged to find other ways of testing the hypotheses.

(4) The teacher may need to help the student determine precise quantities in some instances. The initiative should not be taken from the students, however.

(5) In many instances controls are needed. The teacher may raise the question of the need for a control, and of ways of providing the control.

(6) The adequacy of the test of the hypothesis is an appropriate concern to be raised with each experiment.

Hypothesis: A ninth-grade science student could lift a solid equal in weight to the air in this classroom.

Suggestion: On a sensitive balance weigh a well-evacuated flask, and reweigh with valve open.

Hypothesis: Water that has been boiled will freeze faster than water that has not been boiled.

Suggestion: Use freezing compartment of an electric refrigerator. Try quantities of water so prepared.

Hypothesis: A fisherman can "weigh" a fish using only a ruler and a fishing pole of known weight.

Suggestion: Moments of force can be involved.

Hypothesis: Objects that are good absorbers of heat energy are also good radiators.

Suggestion: Paint two vegetable or coffee cans and lids—one dull black, the other aluminum. With thermometers compare radiation rate when each contains hot water with absorption rate when each contains cold water.

DEMONSTRATIONS

QUICKIES — A Collection of Classroom Demonstrations and Devices for the Teaching of Science

(See Subject Index P-337)

The Science teacher often has a need for quick, spectacular attention-demanding items to enhance his presentation, emphasize a principle, fix a fact, or condition the class for further learning. We hope the following "Quickies" may serve the above needs for you.

1. Spontaneous ignition can be effected with a half teaspoon of sodium peroxide placed on a two-inch cone of starch, sawdust, or finely chopped paper. Lay a small chip of ice on the cone. Sufficient heat and oxygen will be released by the reaction of water from the ice with the sodium peroxide to ignite the material. Kindling temperature and oxidation can be discussed following the demonstration.

2. Structure of a Bunsen flame can be demonstrated by adjusting the flame to above five centimeters and holding a splint horizontally at various levels. Heat intensity for each level will be indicated by the degree of scorch on the splint. This may be varied by using a plain card held perpendicular and slightly tilted in the flame. A scorch pattern will appear showing heat intensities of various areas of the flame. A wire gauze held in the flame will show by its glow the same conditions. Probe the flame with a small thermocouple connected to a sensitive ammeter and interpret.

3. Allow students to check the pH of their own saliva by using Hydrion paper. The color chart (usually on the Hydrion vial) will indicate quite a range of pH through the class.

4. Molecules of water have spaces between them as evident when a long test tube or graduate is filled three-fourths full of water and then completely filled carefully to capacity with alcohol. Place thumb over end of container and invert to mix the liquids. The container will no longer be filled to capacity.

5. Using a small container rather than a large one in a gas generator gives a quicker yield of undiluted gas. Carbon dioxide can be made quickly by heating sodium bicarbonate in a test tube generator.

6. Dramatization of valence in simple reactions can be shown by two girls each holding the other's hands (representing oxygen molecules) and four boys, each with one hand in his pocket but, holding another boy's hand (representing hydrogen molecules). The three molecules represented will break apart at the introduction of a suitable catalyst (represented by a popular dance tune) to form H-O-H.

7. One demonstration seldom offers so many illustrations as does "Barking Dogs," yet remains so simple to perform. Dissolve a small amount of white phosphorus in carbon disulfide. A few drops of this solution on filter papers placed on top of a number of empty glass cylinders of varying capacities will illustrate:

a.—Solubility and physical change as P dissolves in CS_2

b.—Evaporation as CS_2 evaporates leaving P on filter paper

c.—Settling or diffusion of a heavy gas as CS_2 mixes with air in cylinders

d.—Spontaneous ignition as P catches fire on paper

e.—Oxidation and combustion as P catches fire and paper burns

f.—Combustion and explosion as CS_2 and air explode in cylinder

g.—Incomplete combustion as evident by sulfur deposited on cylinder walls

h.—Natural frequency of cylinders differs as pitch of explosion differs.

8. Is so-called suction a push or a pull? Arrange a flask fitted with a two-hole stopper and a glass tube extending well down into the flask, which is completely filled with water. A good-natured student is asked to "suck" water through the glass tube while the instructor holds his finger over the other hole of the stopper. On student's failure to get any water out of the flask, the instructor might remark, "Jim is not as big a sucker as we thought." After appropriate comments and removing his finger from the hole, the instructor asks the boy to try again. Suddenly the sucker succeeds. This is followed by the explanation, after laughter subsides, showing how the experiment answers the problem.

9. Mix a little concentrated sulfuric acid and potassium permangante in an evaporating dish. Dip a glass rod into the mixture and immediately touch the rod with attached mixture to the wick of an alcohol lamp. The alcohol ignites.

10. To demonstrate how water aids chemical reaction, add about a gram of potassium bitartrate with an equal amount of sodium bicarbonate to a test tube. Shake and note no reaction. (Explain that these are the essentials of cream of tartar baking powder which may keep for months on the grocers shelf.) Add a little water and the effect is evident. Ions are

more active than atoms or molecules and water probably acts as a catalyst or at least promotes ionization.

11. Oxygen may be prepared by the action of enzymes in yeast on six per cent solution of hydrogen peroxide, surface action of manganese dioxide on hydrogen peroxide, heating sodium nitrate, or the interaction of sodium peroxide on water.

12. Match sticks are chemically treated except the tip where they are held by machines during the process of manufacture. Burn a match completely and show the differences between the ash or char left of the treated and untreated region.

13. Mix one part sugar with three parts potassium chlorate. Incorporate Na, Ba, Sr, Cu, and BO_3 with portions of the mixture on a long trough. Light one end and observe the different colors which appear in the flame.

14. Crystallization of a supersaturated solution can be shown easily by adding sodium thiosulfate to hot water and letting it cool slowly. Scratching the test tube causes the contents to become practically a solid in short time. Melt sodium acetate in its own water of crystallization by using a double boiler. The resulting supersaturated solution behaves in a spectacular manner.

15. The gas laws may be illustrated by a device prepared by drilling holes near each end and in the center of a small board about the size of a yardstick. Label each hole appropriately, Pressure, Temperature, and Volume. Show by pivoting at center hole (Temperature) if temperature remains constant and pressure rises the volume will lower (decrease) etc. Other variations will show different aspects of the laws.

16. Light gases diffuse downward. Fill a wide mouth bottle with hydrogen. Invert over a like bottle filled with air. While waiting for the diffusion to take place be democratic and allow the class to vote for what they think is most likely to happen. These possibilities may exist: (a) the hydrogen being lighter will remain in the top bottle (b) the gases will mix together (c) all the hydrogen will go to the bottom bottle (d) most of the hydrogen will remain in the top bottle (e) non-voters do not know what will happen. At the end of about five minutes test each bottle. Imply that MANY people vote with too little facts and information.

17. Build a miniature volcanic cone with deep depression in top. Place in the depression some ammonium dichromate mixed with a small amount of powdered magnesium. Push a piece of magnesium ribbon into the mixture. Light the ribbon to ignite the mixture. A realistic volcanic action ensues.

18. A "Halo" type shampoo poured on a small amount of manganese dioxide in a graduated cylinder will produce copious lather on addition of a solution of hydrogen peroxide.

19. Aluminum powder mixed with iodine will ignite when a drop of water is added.

20. The patriotic colors are produced by pouring sodium hydroxide solution into three beakers containing one each of the following solutions: phenolphthalein, lead acetate, and copper sulfate.

21. Lead ions combined with iodide ions produce lead (II) iodide which, when washed and recrystallized from hot water, produce interesting golden crystals.

22. A handkerchief saturated with 70% alcohol diluted with an equal amount of water will not scorch or burn when the alcohol is ignited. Keep the handkerchief moving.

23. Diesel or fuel oil can be further purified by shaking with concentrated sulfuric acid in a separatory funnel.

24. An interesting pulsating action, "mercury heart", can be observed by placing a small globule of mercury in a 5% solution of sulfuric acid in a shallow watch glass. Touch the mercury with an iron needle fixed in a cork and held steady by some mechanical support.

25. Pierce gelatine or jello with a needle having formic acid on it. The gelatin will form a blister or swell as a person does when stung by a bee.

26. Most substances, even glass, are soluble in water. Grind very fine a small amount of glass and put in a test tube with about 5cc of distilled water. Add phenolpthalein and note that it must be dissolving.

27. Solubility of ammonia gas is quickly demonstrated by putting five ml of ammonium hydroxide in a 500 ml flask equipped with a one-hole stopper, glass tubing drawn to a nozzle on one end, and attached to long heavy rubber tubing. Heat the flask and ammonium hydroxide until the ammonia gas comes from the open end of the tube. Place tube end in water and await action.

28. Conservation of energy—support heavy pendulum from ceiling, draw back against nose, with your head against the wall. Release pendulum bob and stand nonchalantly awaiting its return. It cannot rise to greater height than that from which it started. You are safe if you do not move!

29. A simple cloud chamber can be made from a gallon jug fitted with a one-hole stopper with a short piece of glass tubing. Blow into the jug through the glass tubing to increase pressure. Put finger over end of tube and pull stopper, suddenly reducing the pressure. No cloud is formed. If a lighted match is dropped into the jug and the performance repeated, a cloud will form.

30. Call this tubeless television. Project a lantern slide with a few simple words (i. e., That's All) cut in a piece of metal foil so that the image is in mid-air. Direct beam of lantern out through open door so that it does not attract attention. Wave a white wand in the plane of image. Persistence of vision creates a complete image, apparently materialized in space.

31. Place a copper (penny) on glass slide on micro-projector. Put silver nitrate solution around copper and watch silver crystals form on screen. Note many peculiar characteristics they exhibit.

32. Action and reaction. Place plank on rollers (dowlings). Mount massive load on small cart on plank. Attach rubber bands to plank and cart, stretching and tying back with thread or string. Burn thread to release system. Road goes one way, cart goes other.

33. Into a small box place small objects and seal box closed. Students can examine box, blindfolded, and tell you: a. How many pieces are in the box. b. The shape of the pieces. c. How heavy the pieces are (density). d. How big the pieces are. e. The color of the pieces. By doing this the student has reason to believe that scientists may know something about the atom even though it has never been seen; as he has not seen the objects in the box.

34. Alcohol, carefully floated on concentrated sulfuric acid in a test tube, exhibits flecks of fire at the intersurface when potassium permanganate crystals are allowed to fall through the liquids.

35. 42b Natural acid-base indicators can be had in such common foods as blue-berry juice, red cabbage, carrot, beet, etc. Determine over what range of pH they operate.

36. Paper chromatography can be quickly demonstrated by placing a spot of most any ink near one end of a strip of filter paper which touches water.

37. Find the center of gravity of a stick held horizontally across the fingers of both hands. Center of gravity will be at the point where the fingers come together.

38. Mark the center of gravity of a hammer with a spot of color. Toss the hammer into the air with a spin and note that the spot is the most stationary point.

39. Clamp an iron rod to a broom handle near its center. Hold broom handle in both hands with rod extended horizontally. Attach a weight at different distances from the handle and note how torque increases. Lever arm has real meaning here.

40. Show conservation of energy in a swinging pendulum by noting that it returns to the same level each time. Place an obstruction below the point of rotation so that the arc of swing will be changed. Change the obstruction to a point one half the distance between the lowest and highest levels and again below this point. Explain why the bob loops over the obstruction.

41. Evidence that one may see the sun below the horizon can be visualized by looking at a penny in a bowl filled with water. Note that the penny can not be seen over the rise of the bowl unless there is water in the bowl.

42. Select two test tubes so that one barely fits inside the other. Partly fill the larger with water and float the smaller one on the water. Invert tubes and see the water spill out but the smaller tube falls up.

43. A coiled platinum wire suspended from rubber stopper in a flask filled with ammonia gas and air will glow for about ten minutes. Blow over the mouth of flask to replenish oxygen.

44. Have pupils move around the room as sun, moon, and earth to show effect of rotation, revolution, tilt of earth on axis, etc.

45. A burning match head pressed against a silver coin shows direct combination between sulfur and silver.

46. Suspend a bar magnet on a string. Rotate another magnet under it to show transfer of magnetic energy to mechanical energy. What changes the direction of poles? How can the change be effected without human movement?

47. A Cartesian diver can be made with a Coca-Cola bottle full of water and a match head. Keep breaking off the match stick until the head barely floats. Thumb pressure on the mouth of the bottle makes these little divers zip up and down in the bottle.

48. Flame analysis can be done without the expensive platinum wire and without the necessary cleaning before each test. Dissolve a small amount

of the salt to be tested in a few milliters of alcohol. Ignite the alcohol solution in a clean dish and notice the color.

49. Set up a long glass tube filled with water and containing a test tube as a Cartesian diver to operate with a squeeze bulb. The apparatus can be used for demonstration of principles of Archimedes, Pascal, and Boyle.

50. A relatively cold flame may be produced by igniting a mixture of carbon-tetrachloride and carbon disulfide (or water and alcohol). In preparing the mixture first prepare a mixture with too much carbon tetrachloride (or water) so that it will not ignite. Add a small quantity of the carbon disulfide to a portion of the mixture and test for the right temperature. A handkerchief may be dipped in the mixture and held in the hands while burning if it is kept moving.

54. To demonstrate Bernoulli's principle cut a circular piece of cardboard slightly larger than the end of thread spool. In the center of the circular cardboard push a straight pin to the head. Set the spool over the pin point and down on the cardboard. Blow in the other end of the spool. The cardboard will cling to the spool as long as there is air motion through the spool.

52. Cut a four-inch piece of wire from a coat hanger. Bend one-half inch back on one end so that leather belt will slip in the hook. Support other end on finger and belt will hang in space as on "sky hook."

60. Submerge a beaker in a glass container of water filling the beaker with water. Invert the beaker upside down position under water. Invert another beaker and submerge so that air is trapped in it. Pour air from one beaker into the other, pouring up. Note fluid nature of the gas.

54. Fill a flask two-thirds full of water and bring to boiling. Cork the flask and invert. Place ice cube on bottom of flask and see water begin to boil again. If the flask is corked with a one-hole stopper with a glass tube extending almost to the bottom of the flask, boiling can be effected by reducing the pressure of the entrapped air.

55. Wave motion and standing waves can be demonstrated by attaching a string to most any small electric motor or vibrator. An electric shaver is ideal. Hang weights of varying amounts on the string to change wave length and freguency.

56. Mix sand and lead oxide for an ore. Put mixture in a test tube with water and mineral oil and shake well. Note the separation of the mineral and point out "the gangue's all there."

57. A wooden slat is covered with a newspaper except for a few inches which project beyond the edge of a table. The protruding slat is struck by a bat and it breaks instead of tearing the paper.

58. Put equal quantities of water in two small beakers. To each add one of the following chemicals in equal amounts. Dissolving barium oxide is exothermic while dissolving ammonium nitrate is endothermic. Pass the beakers around for inspection.

59. The force of normal external air pressure is sufficient to collapse a rectangular varnish can. In a clean can place a few tablespoons of water and bring it to a boil, to expel the air with the water vapor. Close the cap tightly as soon as water boils vigorously. Cool the can by dashing cold water on it.

60. Cotton or filter paper saturated with turpentine and put into a quart fruit jar or wide mouth bottle of chlorine gas will spontaneously react. Have jar cover handy to prevent soot from covering the room.

61. A copper strip or wire suspended in a silver nitrate solution produces a "silver tree" by the replacement reaction.

62. A dry plastic sponge can be measured for volume. Ask how much water you can pick up with it. When wet, it may pick up more than its initial volume. It expands slightly and is mostly a "lot of air holes fastened together."

63. Arrange wood matches closely on a soft board by means of straight pins placed through them at their midpoint. Hold the board upright and ignite the bottom match. The others will follow in turn to demonstrate a chain reaction.

64. Three students each holding a rod of a different substance in a flame, will demonstrate the difference in conductivity of heat by their object from the flame. Use about the same sized rods or iron, aluminum, glass and copper.

65. Colored crayon marks on white paper viewed through colored bits of glass shows color filter. Make drawings of bird in cage with appropriate colored chalk and let bird out of cage by viewing through colored glass.

66. Games can make both learning and instruction a pleasure. Build puzzle of jumbled letters for other students to solve. An example: (word definition)

Regical — Great ice sheet (glacier)
Isosfsl — Traces of past in rocks (fossils)

67. Some properties of water make interesting conversation pieces. Demonstrate that ice is lighter than water by placing large icicle in milk bottle (ice cube may be used). Add cold water to fill jar while holding ice under the water. Let ice float and observe what happens as the ice melts.

68. The effect of tobacco smoke on fish can be demonstrated by arranging a train of two flasks, each filled with water and one containing fish. A cigarette is smoked through the water containing the fish by siphoning the water from the other flask.

69. Heat strongly some protein in a test tube having pieces of litmus paper and lead acetate paper over the lip. Blackening of protein shows its carbon content; litmus turns blue, indicating ammonia; lead acetate paper turns black, indicating the presence of hydrogen sulfide; water condenses on side of the test tube.

70. "Moth balls" rolled in sodium bicarbonate and put into a cylinder of very dilute hydrochloric acid will rise and fall with regularity.

71. Print with capital letters such words as CHICK BOX or FIRST CHOICE. Place a mirror over the top half of the words and perpendicular to the plane of the paper and observe the reflected part of each word with that visible.

72. An interesting conversation piece can be made from a salt box. In the center of one end punch one hole with a sharp needle. About the center of the other end punch three holes at the corners of an equilateral triangle about two millimeters apart. Look through the one hole and see the three holes. Look through the other end at the one hole and explain what is

seen. Label the box "Drunk-O-Meter" and list the following directions: 1 hole—sober, 2 holes—nippin, 3 holes—dog drunk, 4 holes or no holes at all—dead drunk.

73. To demonstrate the center of gravity outside of a body and the criterion for stability, borrow two pocket knives from students. Push blades firmly (but carefully) into a pencil near the sharpened end with the handles beyond the point of the pencil. Balance it point downwards on your finger. If the center of gravity falls below the point of balance the system will be stable.

74. The stabilizing action of colloids is a principle utilized in the "Foamite" fire extinguisher. Into each of two tall cylinders or hydrometer jars pour a soluton of sodium bicarbonate. Add a teaspoon of licorice extract to one. Add aluminum sulfate solution to each and notice how carbon dioxide bubbles subside rapidly in one while foam rises over the top of the other container and spreads.

75. Bernoulli's principle can be shown by balancing an inflated balloon or beach ball on a jet of air from the output end of a vacuum cleaner. The balloon will hover near the ceiling and will not fall off although tipped a considerable angle. A ping pong ball balanced on a fine jet of water will illustrate the same.

76. Many organic substances, dead and alive, show interesting characteristics under black light. Cockroaches are multicolored under ultraviolet light.

77. For quick demonstration of colored flame, ion color, or burning of metals, keep salt shakers filled with powdered metals such as iron, aluminum, magnesium, zinc, and antimony. Dust these into a Bunsen flame. Salts of strontium, lithium, barium, copper, and sodium can be sprinkled into a flame by the same method.

78. Pour copper sulfate solution over coarse iron filing on a filter paper. The blue solution on coming through the filter will be colorless. If a small amount of acid was placed in the collecting container, when the solution is poured back through it will again be colored.

79. Ionization in a frame can be shown by holding a lighted match near a charged eletroscope. Charged pith balls or balloons lose their charge rapidly when a flame is brought near.

80. Light rubber balloons suspended from long silk strings act as demonstration electroscope when charged by rubbing with woolen cloth or fur. Individual balloons can be made to stick to flat surfaces such as walls or ceilings by rubbing them on clothing.

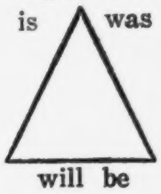
81. Cut a six inch circle of plywood or press board. Cement a small cork at its center. Drill a very fine hole through the disc and cork. Inflate a balloon and fasten its mouth over the cork. Place the apparatus on a smooth surface to see almost frictionless motion on the cushion of air.

82. Strike a match and place the lighted match between the tynes of a tablefork. Watch the match 'go out' as the flame reaches the metal fork and the heat is conducted away.

83. Minemonics are useful memory devices and should be used with emphasis on the facts rather than on the device for remembering. CREAM

may mean the five kinds of energy: chemical, radiant, electrical, atomic, and mechanical. Its plural might suggest the most profitable source of future supply.

84. Analogous inference, although not true or real, may be a hitching star for some philosophy that affords a solid foundation for work. A triangle can be used to show relative importance of study and application to one's future. What you "is" today determines what you "was" from any future date. Both of what you "is" and what you "was" determines the length of your "will be" or future base line.



85. Rubber bands or strips can be tied together in bundles and charged by stroking with fur or by other means. A lighted match near the repelling strands will cause them to collapse.

86. Done with a lot of flourish, this brings down the house! The mechanics of the friction, forces, and inertia involved make interesting conversation. Set a glass two-thirds full of water about three inches from the edge of a table. On the glass place a pie tin. On the pie tin and directly over the glass place a spool on end. Place an egg (fresh if you are confident) on the spool. With one foot on the bristles of a springy broom, pull back the handle and aim at the pie tin. The spool rolls on the table, the pie tin skoots to the floor, the glass and water remain unmoved on the table with the egg unharmed in the water.

87. Blow or suck on the small end of a funnel containing a ping pong ball. The ball will not fall out even though the funnel is inverted, so long as air is moving between the ball and funnel wall.

88. Look through a paper tube at some distant object with the right eye while holding a book over the other eye and close to the tube. It will appear that one is looking through a hole in the book.

89. Draw a circle in the center of piece of white paper with colored crayon. Stare at the circle at arms length for a time, then look at a blank wall. A circle of some other color appears on the wall.

90. Boil water in a paper cup. The paper will not burn until the water has boiled away.

91. Considerable heat is generated in stretching a rubber band. Hold the band against the upper lip and extend it quickly. Allow the rubber band to contract rapidly and note that it absorbs heat.

92. Stretch a rubber band tightly and rub against an electroscope. Determine the nature of charge produced.

93. Combing the hair near the aerial of a radio produces static.

94. Suspend thermometers insde and outside a large closed bottle to observe the hothouse effect. The same effect can be observd by measuring the temperature inside a closed automobile and the outside temperature.

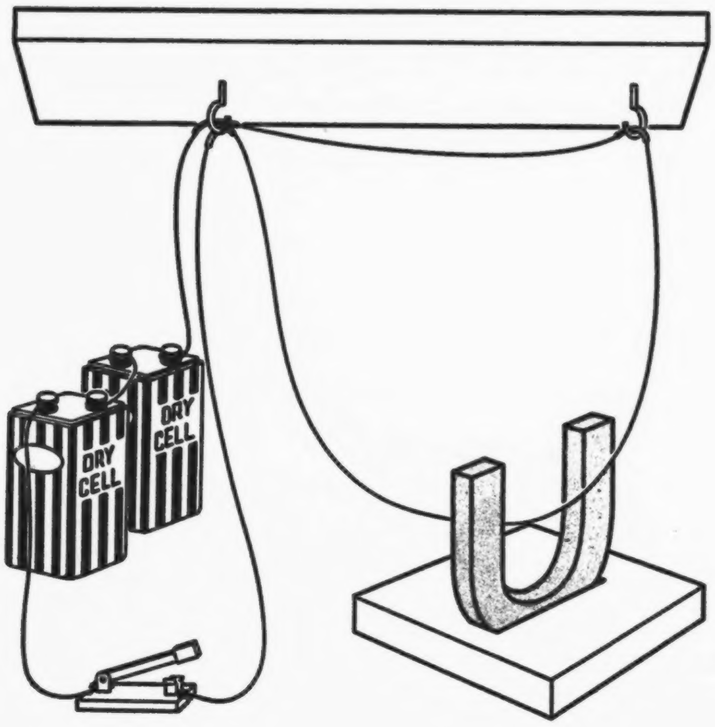
95. Float a needle or razor blade on water by aid of its surface tension. Weaken the surface tension with a speck of detergent.

96. Scrape flecks of gum camphor onto a water surface and see the pieces propel themselves over the surface. A drop of olive oil on the surface stops the action.

97. Identify a fresh egg from one that has been boiled by spinning them on a flat surface. One stops motion sooner.

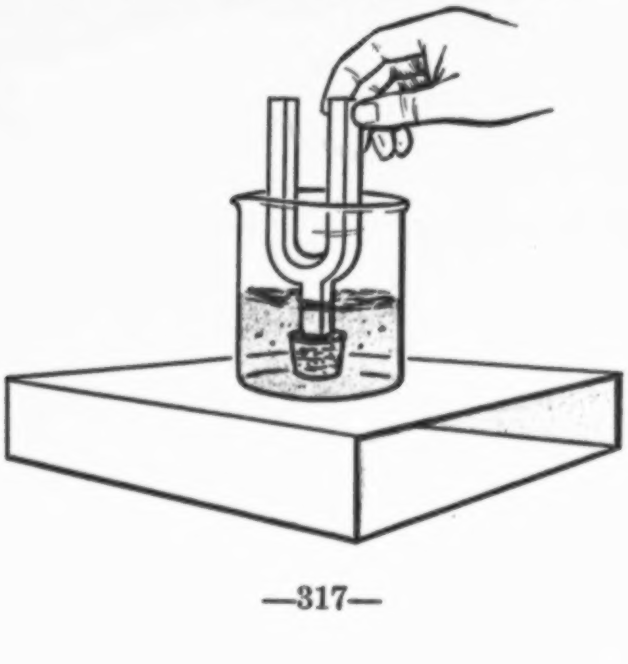
EFFECT OF A MAGNET ON AN ELECTRIC CURRENT

Form a piece of heavy wire into a U-shape and suspend it from two hooks in a board. Connect the ends of the wire to a battery. Include a switch in your circuit. Position a U-magnet so the wire is between the poles. Close the switch. Notice what happens. Open the switch and observe what happens.



SOUND TRAVELS THROUGH WATER

Remove one end from a small box. A box about 8" x 6" would be a good size. Place a beaker of water on the box as illustrated. Attach a piece of cork to the stem of the tuning fork. Strike the tuning fork and hold the cork in the water. What do you observe?



PART V — APPENDICES

EVIDENCES OF A GOOD SCIENCE PROGRAM

1. Teachers participate in formulating over-all objectives of instruction.
2. There is evidence of purposeful planning leading to objectives.
3. Students continue practices in the use of skills associated with the processes of scientific inquiry.
4. The program is directed at growth in understanding basic theories of science. Understanding is developed inductively and deductively.
5. The program encourages development of desirable attitudes toward science.
6. The program encourages development of desirable characteristics of scientists.
7. The program has continuity or sequence from grades 1 through 12.
8. The program is planned, but flexible and recognizes new scientific developments and regional differences.
9. Facilities and opportunities are provided for individual differences, as well as group interests.
10. The program provides first-hand experiences with materials and phenomena, including open-ended experimental activities.
11. The program provides for growth and the use of manipulative skills and attitudes associated with laboratory processes.
12. The program leads to an awareness of both the orderliness and the randomness of natural phenomena.
13. The program develops an appreciation of the scientific enterprise.
14. The program makes use of a variety of up-to-date resources and materials.
15. The program is under the guidance of competent teachers who are oriented toward science and understand the interests and energies of youth.
16. The program makes use of instructional aids and materials selected on the basis of their appropriateness to developing desired understanding, intellectual and manipulative skills and attitudes.
17. The program draws upon resource people as well as material resources available from the community.
18. The program contributes to other curriculum areas and in turn is enriched by them.
19. The program provides experiences for students to "learn by being" as well as to "learn by doing", in areas in which they are interested. (Freedom and encouragement to investigate by themselves.)
20. The program gives emphasis to the mathematics of science.

STUDY TECHNIQUES IN SCIENCE

I. **Reading Strategy**
  A. Read for a purpose
    1. Determine what your purpose or objective is for reading the material.
    2. Train yourself to ask silent questions like these:
      a. Why am I reading this material?
      b. How shall I proceed?
      c. What do I want to find out?
      d. What points should I remember?
  B. The Pre-reading Survey
    1. Look quickly through the entire passage to be read. (Seeing the material first as a whole.)
      a. Glance at illustrations and their captions.
      b. Read the introductory paragraphs.
      c. Read the summarizing last paragraphs.
    2. Develop questions about the passage. (Seeing the material in its various parts.)
      a. Ask questions on items that arouse your curiosity. Make a mental note or write these questions down.
      b. Convert headings themselves into questions.
  C. Proceed with close reading.
    1. Distinguish general statements from supporting details.
    2. Organize what has been read to see the important relationships.

II. **Other Useful Reading Devices.**
  A. Recognize kinds of paragraphs.
    1. Three general types of paragraphs:
      a. the narrative, or running account;
      b. the cause-and-effect paragraph, in which you must sense the relationship;
      c. the example, which presents an idea in more familiar terms.
    2. Recognize the cue that indicates that a careful word-by-word reading is required.
  B. Apply ideas gained from reading.
    1. Try experiments.
    2. Look up information on material not explained.
  C. Draw conclusions.
    1. Form your own generalizations.
    2. Pull the facts together.
    3. Summarize what has been read.
  D. Evaluate the evidence.
    1. Be alert to points of evidence in the reading material.
    2. Judge whether the writer has offered evidence to suport his conclusions.

III. Four Important Factors in Reading.

- A. Attention and application
  - 1. Be alert as you study, and your results will be to:
    - a. learn more;
    - b. learn more easily;
    - c. learn more quickly.
- B. Reading rate is determined by:
    - a. type of material being used.
    - b. purposes for reading.
- C. Vocabulary
  - 1. Helps found in textbooks:
    - a. Meanings and pronunciations given in body of text.
    - b. Glossary.
  - 2. Other useful devices
    - a. Analyzing words.
    - b. Discussing the terms after a study assignment.
    - c. Studying for spelling tests.
    - d. Using the words in sentences.
  - 3. Special vocabulary study methods.
- D. Outlining and note-taking are necessary.

See Coronet films or other films on reading.

Teachers Reference: Teacher's Manual, *Science/A Search for Evidence*, Macmillan Company, 1960, pp. 12-14.

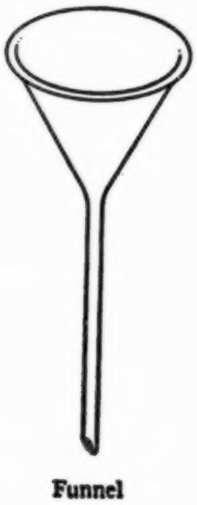
LIST OF BASIC SCIENCE EXPERIMENTAL EQUIPMENT
FOR GRADES 7-9
(MINIMUM LIST)

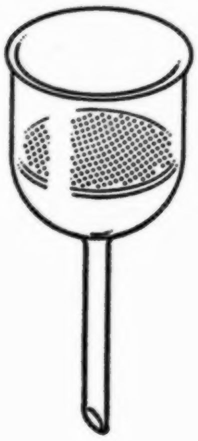
Name of Item	*Quantity*
Aquarium, 6 gal. or larger	1 per science room
Atom model	1
Balance:	
Spring	6
Trip scale, Harvard type	2-8
Ball and ring	1
Barometer, aneroid	1
Batteries	8 or more
Cell, Voltaic	8
Bell, electric	1 per sci. room
Biological materials, representative materials from the various phyla	1 set
Bottles: Reagent	24
Brushes, assorted	2 sets
Burners:	
Bunsen or propane gas, portable	6
Centrifugal force demonstration apparatus for use with rotator: Axis of rotation, hoop	1
Clamps:	
Burette	8
Test tube, Stoddard	15
Compasses, magnetic	15
Crucibles	15
Cylinders: Aluminum, brass, copper, steel, waterproofed wood, glass	6 of each
Dishes:	
Pyrex	quantity
Petri	24 or more
Disks, acoustic	1
Disks, color	1 set
Dissecting sets	8
Dynamo, hand powered or	
Dynamo and motor set	1
Electrolysis demonstration apparatus	1
Electroscope	1
Flasks:	
Erelmeyer	8
Florence	8
Forceps	8
Funnels, glass	8
Graduated cylinders	8 of each size
Gyroscope	1

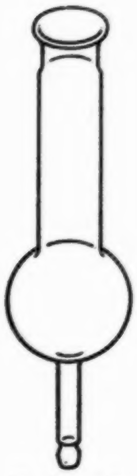
Hot Plate, electric	1
Rydrometers: Battery with tremometer	1 or more
Hygrometer, wet and dry bulb	1
Lamps, electrical (small)	30 or more
Lenses: Set consisting of: concavo-convex, convexo-concave, double concave, double convex, plano-concave, & plano-convex	1 or more sets
Levers, Simple (meter stick)	6
Magnets	6 of each type
Medicine droppers	12
Ammeters:	
AC Portable laboratory type	1 or more
DC ammeter	1 or more
Voltmeters	
AC voltmeter	1 or more
Triple scale	1 or more
DC triple scale, portable laboratory type	1 or more
Meter stick	6
Microscope: (Specifications for biology and senior high school)	
Compound standard	6
Microscope slides (prepared) Gen. Sci. Set	2-6
Microscope slides (clear)	200
Microprojector	1
Minerals: Set of minerals and rocks: metallic minerals: hematite, limonite, green malachite, bauxite, galena, sphalerite, beryl, pyrite, cinnabar, manganite.	1 set
Mirrors:	
Plane glass	8 sets
Motors, electric: St. Louis	2
Power unit, electric, 110 v	1
Prisms:	
Equilateral	8
Tackle blocks:	
Single	8
Double	8
Resistances:	
Resistance box	1
Resistors, assorted	2 sets
Rheostats:	
Slide wire	1 or more of different ratings
Rods, friction:	
Vulcanite	8

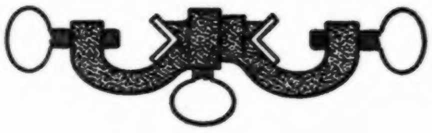
Rotator:	
Hand driven	1
Scissors	8
Sockets, electrical	30 or more small, several large ones
Switches, electrical, knife	8
Telegraph set (Key, sounder, relays)	1
Telegraph set (Receiver, transmitter)	1
Test tubes	10 dozen
Thermometers: Centigrade and Fahrenheit	8
Stoppers, assorted	quantity
Troughs, pneumatic	8
Tubing, rubber	100 or more feet of different sizes (must fit glass tubing)
Tubing, glass	100 feet
Tuning Fork set	1 set
Weights:	
Set of gm. weights	as many sets as balances to use them.
Hooked weights	2-8 sets

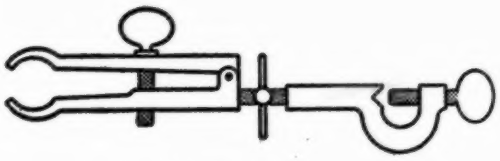
IMPORTANT LABORATORY EQUIPMENT

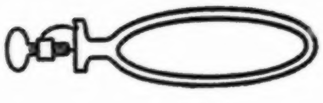

Funnel

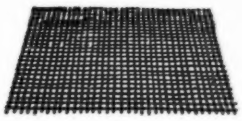

Buchner funnel

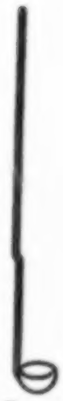

Drying tube

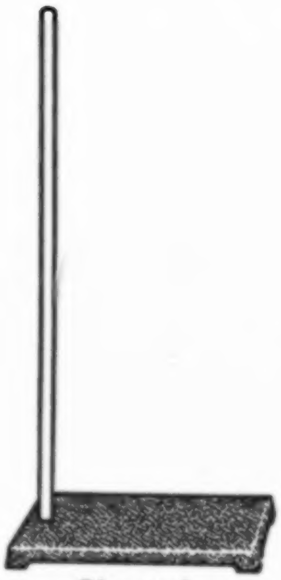

Iron clamp

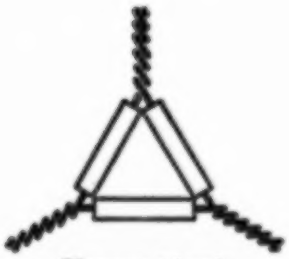

Burette clamp

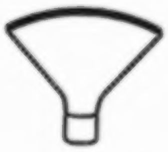

Iron ring

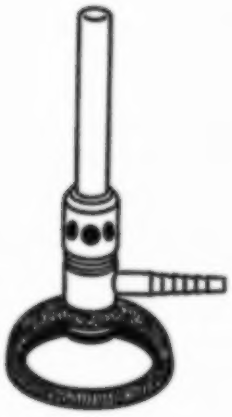

Wire gauze

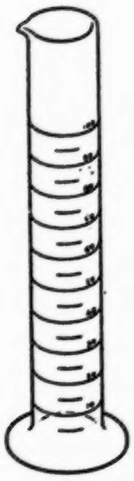

Deflagrating spoon


Ring stand

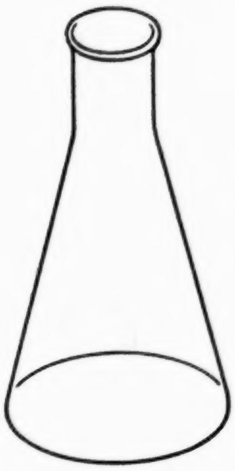

Pipestem triangle


Wing top

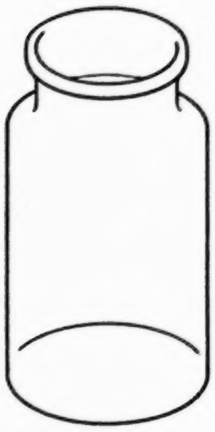

Burner



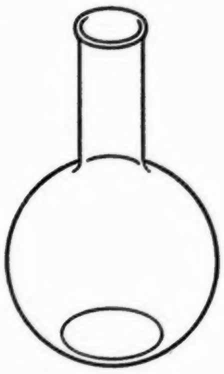
Graduated cylinder



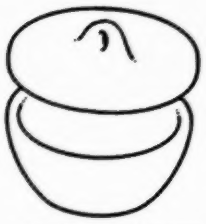
Erlenmeyer flask



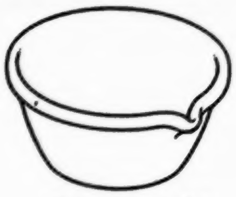
Bottle



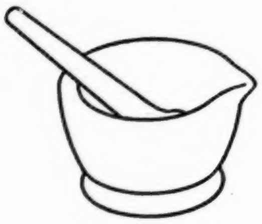
Florence flask



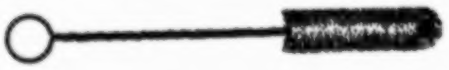
Crucible and cover



Evaporating dish

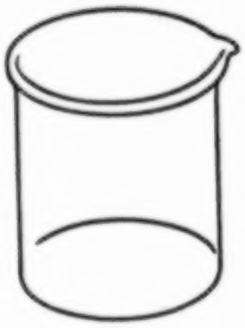


Mortar and pestle



Test tube brush

Watch glass



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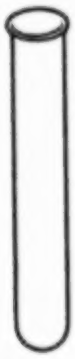

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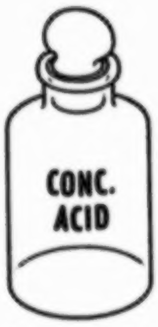
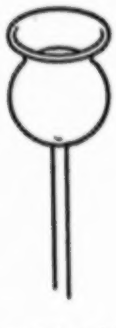
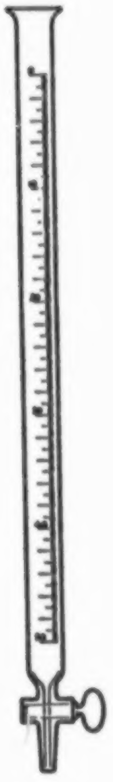


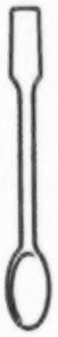
Reagent bottle



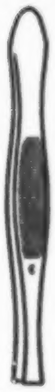
Thistle tube



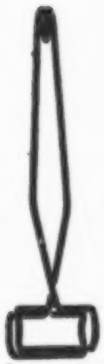
Burette



Spatula

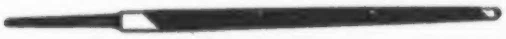


Forceps

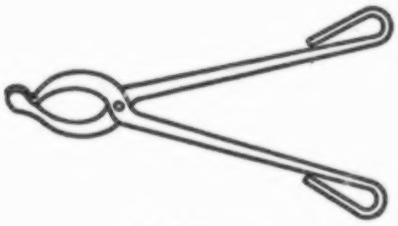


Test tube clamp

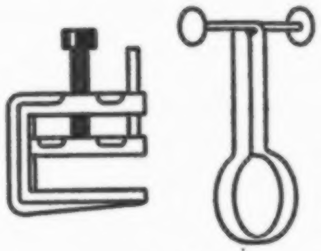
Pipette



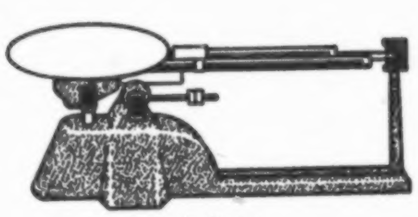
Triangular file



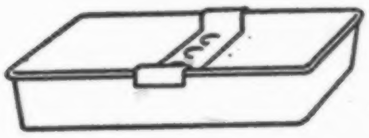
Crucible tongs



Pinch clamps



Balance



Water trough

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PUBLICATIONS AVAILABLE THROUGH THE STATE WILDLIFE MUSEUM JACKSON, MISSISSIPPI

Freshwater Fishes in Mississippi by Cook	$3.00
Salamanders of Mississippi by Cook	.50
Snakes of Mississippi by Cook	.50
A Key to the Amphibians and Reptiles of Mississippi by Cliburn	.50
A Preliminary Check List of the Vertebrates of Miss. by Gandy	.50
Alligator and Lizards of Mississippi by Cook (temporarily out of print but may be reprinted)	.50
"General Information on Mississippi Bird Life" by Gandy (one copy given free to teachers)	

FILMS

Films Suggested in the Guide:

McGraw-Hill Text Films, 330 West 42nd St., New York 36, N.Y.

1. Electric Circuits
2. Energy
3. Inertia of Motion
4. Action and Reaction
5. Reflection
6. Refraction
7. Sound

Southern Bell Telephone and Telegraph Co., Contact local telephone company.

8. Gateway to the Mind (Obtained on loan)
9. Music in Motion
10. Ferromagnetic Domains
11. The Science of Sound
12. The Sounds of Frequency
13. The Strange Case of the Cosmic Rays
14. The Unchained Goddess
15. Our Mister Sun
16. The Thread of Life

Shell Oil Company, Film Library, P.O. Box 2099, Houston 1, Texas.

17. Fossil Story (Obtained on loan)
18. How an Airplane Flies
19. Harnessing Liquids
20. Rival World

Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill.

21. What is an Electric Current
22. Electrochemistry
23. How to Produce Electric Currents with Magnets
24. Magnetic, Electric and Gravitational Fields
25. Atomic Energy Series

Modern Learning Aids

26. A Magnet Laboratory
27. Electromagnetic Waves

Coronet Instructional Films, 65 East South Water St., Chicago 1, Ill.

28. Galileo's Laws of Falling Bodies
29. Issac Newton
30. Ocean of Air
31. Water Cycle
32. Water and What it Does

FILMSTRIPS

Filmstrips suggested in the guide:

Encyclopedia Britannica Films, Inc., 1150 Wilmette Avenue, Wilmette, Ill.

33. The Story of Mountains
34. The Story of Volcanoes
35. The Story of Ice and Glaciers
36. The Story of Underground Waters
37. The Story of Rivers
38. Work of Running Waters

Society of Visual Education, 1345 Diveresy Parkway, Chicago 14, Ill.

39. Sun and Its Planets
40. Stars and Galaxies
41. Earth's Satellite—The Moon
42. Why the Seasons
43. Comets and Meteors

Life Filmstrips, Time and Life Building, Rockefeller Plaza, New York 36, N.Y.
    Earth is Born

Curriculum Filmstrips, Herschel Smith Co., Jackson, Miss.
44. Air in Action
45. Thunderstorms
46. The World We Live In
47. Weather Maps

Eyegate House, Inc. 146-01 Archer Avenue, Jamaica 35, N.Y.
48. The World of Insects
49. Animals and their Ways
50. The Fish
51. Birds and Their Songs

The Jam Handy Organization, 2821 East Grand Blvd., Detroit 11, Michigan.
52. The Atom and Its Nucleus
53. Understanding the Atmosphere
54. Space and Space Travel
55. The Earth in Space
56. Simple Machines
57. Inclined Plane, Wedge Screw
58. Looking at Sound

59. Almanac Films, Inc.
    The Earth—The Changing Surface
    How Crystals Are Formed
    Rocks and Minerals
    Rocks, Minerals, and Soil
    Energy and What it Does
    Cells—Building Blocks of Life
    Microscopic Life
    Simple Plants and Animals

OTHER FILM SOURCES

59. Almanac Films, Inc. 516 Fifth Avenue, New York 36, New York.
60. American Petroleum Co., Whitney National Bank Building, New Orleans, La. (Obtained on loan)
61. Associated Educational Materials Co., Inc. Glenwood Avenue at Hillsboro St., P. O. Box 2090. Raleigh, North Carolina.
62. Department of Commerce, U. S. Coast and Geodetic Survey, Washington 25, D. C. (Obtained on loan)
63. Educational Audio-Visual Branch. Code AFEE-3. NASA Headquarters. Washington 25, D. C. (Obtained on loan)
64. Educators Progress Service, Randolph, Wisconsin, for *Educators Guide for Free Science Materials.* (Obtained on loan)
65. Metropolitan Life Insurance Co., School Service Dept., 1 Madison Avenue, New York 16, N. Y. (Obtained on loan)
66. Mississippi State Health Department, Jackson, Mississippi. (Obtained on loan)
67. Mississippi State Game and Fish Commission, Jackson, Mississippi. (Obtained on loan)
68. National Aeronautics and Space Administration, Office of Educational Programs and Services, Code AFEE, Washington 25, D. C. (Obtained on loan)
69. National Educational Television Film Service, Indiana University, Bloomington, Indiana.
70. National Teaching Aids, Inc., 386 Park Avenue So., N. Y. 16, N. Y.

71. State Department of Education, Jackson, Mississippi. Contact Supervisor of Audio-Visual Education. Films "Visual Perception," "The World of Dr. Vishniac," "Mathematics and the River," "Project Mohole," "Benjamin Franklin—First American Scientist." (Obtained on loan)
72. U. S. Government Films:
    U. S. Department of Health, Education, and Welfare, Abraham A. Ribicoff, Secretary, Washington, D. C. (Obtained on loan)
73. United States Steel Film Distribution Centers:
    Birmingham Film Distribution Center, Tennessee Coal and Iron Division, General Offices, Fairfield, Alabama. (Obtained on loan)
74. Association Films, Inc. 1108 Jackson Street, Dallas 2, Texas. (Obtained on loan)
75. The National Foundation, 800 Second Avenue, New York 17, N. Y. (Obtained on loan)

(Films available on loan)

ADDITIONAL FILM AND FILMSTRIP SOURCES

76. Audio-Visual Branch, Office of Public Information, U. S. Atomic Energy Commission, Washington 25, D. C. (Obtained on loan)
77. Mississippi Agricultural Extension Service. State College, Mississippi. (Obtained on loan)
78. The Conservative Foundation. O'Hare Books, 719 Broadway. New York, N. Y. 10003 (Films and filmstrips)
79. Churchill Films. 662 North Robertson Boulevard. Los Angeles, California 90069.
80. Robert Disraeli Films. Chemistry Laboratory Techniques. P. O. Box 343, Cooper Station, New York 3, N. Y.
81. The Ealing Corporation. 2225 Massachusetts Avenue. Cambridge, Massachusetts. 02140. Catalog Ealing Film-loops. For 8 mm film-loops.
82. Film Strip of-the-Month Clubs. 355 Lexington Avenue. New York, N. Y. 10017.
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